1921
L97

WIRE NAIL MAKING IN AMERICA

BY

FRANK SOLON LUNEY

B. S. University of Illinois, 1907

THESIS

Submitted in Partial Fulfillment of the Requirements for the

Degree of

MECHANICAL ENGINEER

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

1921

1921
L97

UNIVERSITY OF ILLINOIS

THE GRADUATE SCHOOL

May 16 1921

I HEREBY RECOMMEND THAT THE THESIS PREPARED BY

Frank Solon Luney

ENTITLED Wire Nail Making in America

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

PROFESSIONAL DEGREE OF Mechanical Engineer

A. C. Willard.

Head of Department of Mechanical Engineering

Recommendation concurred in:

A. C. Willard.
G. A. Goodenough
J. M. Snodgrass

} Committee

478045

Digitized by the Internet Archive
in 2016

https://archive.org/details/wirenailmakingin00lune

- TABLE OF CONTENTS -

I. EARLY HISTORY OF NAIL MAKING
(a) Hand Making of Nails 1
(b) Material for Making Nails 5
(c) Nail Industry in England 5
(d) Nail Industry in Colonial America 7
(e) Economic Value of the Nail Industry to the Colonies 8
(f) Output of One Nailer 9
(g) Type of Hammers Used by Nail Makers. 9
(h) Physical Energy Required to Make Nails 10

II. THE WIRE NAIL
(a) History of the Wire Nail 12
(b) Early Methods of Making 13
(c) Its Introduction into America 14
(d) Its Reception by the Trade 15
(e) Ascendancy Over the Cut Nail 16
(f) Standard Sizes of Common Wire Nails 19
(g) Kind of Steel Used 20

III. EARLY NAIL MAKING MACHINES
(a) The Slitting Mill 22
(b) Plate Nail Machine 23
(c) French Wire Nail Machine 25
(d) German Wire Nail Machine 26
(e) Fundamental Features of All Wire Nail Machines 27

IV. AMERICAN WIRE NAIL MACHINES
(a) Early American Inventions 29
(b) Trend of Inventions 30
(c) Later Types of Nail Machines 33
(d) Performance of Various Machines 34
(e) Operating Difficulties Encountered 36
(f) Material Best Adapted for Principal Machine Parts 36

V. AMERICAN WIRE NAIL INDUSTRY
(a) First Wire Nail Factory 39
(b) Growth of the Nail Business 39
(c) Economic Value in Its Relation to Wire Business 40
(d) The Nail Combine and Its Influence 42

- TABLE OF CONTENTS - CONT'D

VI. THE MANUFACTURE OF COMMON WIRE NAILS
(a) The Operating Organization of a Nail Mill . . . 44
(b) Trade Demands for Common Nails 46
(c) Ordinary Range of Nail Machine Sizes 47
(d) Kind of Wire Used 48
(e) Economic Arrangement of Machines and Drives. . 49
(f) Tonnage as a Basis of Wage Payment 49
(g) Advantage of Constant Speed 50
(h) Power Requirement of Nail Machines 50
(i) Trucking of Commodities 51

VII. CLEANING AND POLISHING NAILS
(a) Importance of Cleaning and Polishing Nails . . 52
(b) Nail Tumblers 53
(c) Polishing Material 54
(d) Time Required to Clean 55
(e) Preventing Bent Nails in Cleaning 55

VIII. PACKING AND STORING NAILS
(a) Usual Nail Package 57
(b) Parallel Packing of Nails 58
(c) Packing Machinery 59
(d) Storage of Nail Kegs 59
(e) The Storage of Nails 60

IX. NAIL DIES
(a) Kind of Steel Best Adapted 62
(b) Hardening and Tempering 63
(c) Economic Utilization of Tool Steel Die Scrap 63
(d) Machinery Required 63

X. DESIGN AND DESCRIPTION OF TYPICAL NAIL MILL
(a) Statement of Problem 65
(b) Outline of Design 66
(c) Selection of Nail Machines 67
(d) Building 68
(e) Nail Machine Drives 73
(f) Cleaning and Packing Building 74
(g) Tumbler Drives 75
(h) Sawdust Storage 76
(i) Nail Warehouse 77

- TABLE OF CONTENTS - CONCL'D.

LIST OF TABLES

TABLE I	Standard Sizes of Common Wire Nails . .	19
II	Range of "Brooklyn" Machine Sizes . . .	47
III	Range of "Universal" Machine Sizes . .	47
IV	Range of "National" Machine Sizes . . .	48
V	Range of "Ryerson-Glader" Machine Sizes	48

LIST OF DRAWINGS

PLATE I	General Plan of Nail Department	78
II	Detail Plan of Section of Nail Mill . .	79
III	Detail Plan of Section of Nail Mill . .	80
IV	Sectional Elevation of Nail Mill and Warehouse	81
V	Plan of Cleaning and Packing Department	82
VI	Typical Sectional Elevation of Cleaning Building	83

LIST OF PHOTOGRAPHS

FIGURE I	No. 2 "National" Nail Machine	84
II	"National" Nail Forming Mechanism . . .	85
III	"National" Cut Levers	86
IV	"National" Radius Links	87
V	"Ryerson-Glader" Nail Machine	88

WIRE NAIL MAKING IN AMERICA

I. EARLY HISTORY OF NAIL MAKING.

(a) HAND MAKING OF NAILS. At just what time nails were first used, is an unrecorded event in history, altho it is a well known fact that their use dates back to very early times. Historic evidence of the use of nails is strewn all along the pathway of civilization, mute testimony in the museums of modern times to Man's climb from the days of ancient history to those of modern civilization.

When Man started using wood for construction purposes, it was necessary for him to invent a method of fastening the wood in his structure. The first fastening was a wooden pin, from which in time was evolved the modern nail. The evolution, romantic as it was, has long since become history - some of which is recorded, but most of which is not. Perhaps, because a nail has always been such a common article and so familiar to everyone, the historians passed it by unthinkingly.

The term "nail" calls to mind a strip of metal, rather pointed at one end and with possibly a head on the other end, used for the purpose of fastening pieces of material together, the fastening being accomplished

by driving the strip into the material. The use of nails suggests their making and it is with this feature that we are principally concerned.

Back of all worth while things, there is usually an incentive for the producing and developing of them. In the majority of cases, this incentive can be traced, directly or indirectly, to commerce in which the article in question forms a means of barter and exchange. Such is the case with nails. The demand for nails, developing as a consequence of their adaptability as a building material, was the incentive for their making; and, as time went on and the demand increased to the extent where their making furnished a living for the maker, nail making became a trade.

And so it is that the art of making nails is one of the oldest trades known to mankind. The art is so old, in fact, that its origin is unknown. However, its antiquity may be safely charged with four figures, because nails are frequently mentioned in the Old Testament of the Bible as being made of gold, silver, brass and iron.

The art, as a whole, attracted a cosmopolitan following, because nails were used and made in varying quantities by every civilized country on earth to meet the needs of the builders and their artisans.

In the olden days, before machines were used, all nails were hand made of metal and it is natural to suppose that nail making in very early times was handi-

capped by the non-production of suitable metals. Later on as the demand for nails increased, their making was, no doubt, a considerable spur to the increased smelting of more suitable metals, notably iron. That particular attention was paid to the trade in nail stock is evidenced by the fact that rods of suitable shape for nail making were furnished by the iron manufacturers and known as nail rods. These rods formed an important branch of the early iron industry.

As time went on and the European Continent became more settled, nail making became permanently established. Increased ship building added materially to the trading in nails. The demand was supplied principally by England, Belguim, Sweden, and Holland and to a lessor degree by the other countries. The demand for nails grew and the trade grew accordingly, but still the method of production remained crude. It must be remembered that this was before the days of any except the most simple sort of machinery.

All nails then produced were forged by hand by an artisan known as a "nailer". He worked before a hearth invariably located in his own home where all members of his family, both male and female, big and little, took an active part in the forging. Sometimes two or more nailers shared the same hearth to save coal, but this was the exception rather than the rule.

The growth of the nailers trade very early made

necessary an attempt to standardize the nail sizes as an aid in handling the nails and nail stock commercially. The styles of the nails were designated by terms defining their use such as "deck," "flooring" etc. Each style varied in thickness and length. The thickness was designated as "fine", "barbed" and "strong", while the length was given in inches and the weight in pounds per one thousand nails. Commercially they were designated in size by prefixing a numeral to the term "penny". This latter term is a corruption of"pun" for pound and, during the days of hand forged nails, it indicated the weight in pounds of one thousand nails of a given size. For example, the term "Eight Penny Nails" indicated that one thousand nails of that particular size weighed eight pounds. The nomenclature of this method of indicating nail sizes has been retained somewhat and is used generally to the present day. However, the significance, so far as indicating the weight of any definite number of either wire or cut nails is concerned, has been entirely lost.

The statement made by some writers that the term "penny" refered to the pennyweight of each nail of a given size is without any foundation of facts to support it and the first explanation is the one generally conceded to be correct.

The trade was familiar with over three thousand different sizes and shapes of nails.

(b) MATERIAL FOR MAKING NAILS. Wrought iron was the material which was generally used by the nailers for making the hand-forged nails of old. Until 1855, when the Bessemer process of making steel was invented, wrought iron was the only kind of malleable ferrous metal known, except the better grades designated as "blister" and "crucible" steels. The latter two were a result of continued refining of wrought iron from which the cinder was eliminated, after which the carbon was incorporated. As far as common, malleable stock was concerned, wrought iron alone was known and held a place similar to the low carbon steel of today.

The wrought iron nail stock was supplied from the mills in the form of bars, called nail rods. These rods were sold in bundles and could be procured in various cross-section dimensions, according to the size of the nail to be made. This fact alone saved the nailers a great deal of work, which otherwise would have been required to forge the nails from larger stock.

(c) NAIL INDUSTRY IN ENGLAND. In England, Birmingham was the center of the nail industry, just as it was the center of the iron industry. By the middle of the Eighteenth Century, hearths of the nailers were scattered for miles along the roads of the entire countryside around Birmingham and one could not travel far in any direction from the city out of reach of the sound

of the nailers' hammers.

The nails were made under the domestic system of industry and, for this reason, living and working conditions among the nailers were very unsatisfactory. The employment was controlled by nail masters, who supplied the nailers with the nail rods and paid for the work done. The wages paid were very low, purposely kept so, in fact, by the nail masters. It was necessary for entire families, from the father and mother down to the small children (both boys and girls), to engage in the forging of the nails, for which they would receive only enough for bare subsistence. Both women and children, the entire family in fact, worked long hours in filthy smithies - located, sometimes, in a shed attached to the dwelling, but, in the majority of cases, in their very homes.

At one time, 60,000 people were so employed under the nail masters in the Birmingham district alone, for whom 200 tons of nail rods were required each week.

Because of the difficulty in obtaining the nail rods, other than through the nail master, it was necessary for the nailer to live near a producing center where he was always sure of his supply of rods and also sure of a market for his product. There were a few nailers' hearths scattered promiscuously around the country, but these cared only for a small local demand for various sized nails which would not support a regular

nail maker's business.

As late as 1886 the hand forging of nails in England was still an extensive industry, altho it had passed the turning point of its importance and was doomed to extinction by the adoption of machine made nails. The industry had lost some of the domestic atmosphere by the nailers having been grouped in shops to some extent, altho not universally, and women were still employed in the industry just as their ancesters had been for the past 200 years.

(d) NAIL INDUSTRY IN COLONIAL AMERICA. The custom of nail making in colonial America was about the same as that in England, but was carried on in a very limited manner. The nailer operated his hearth in his home, located close to the seaport, where his nail stock was most easily obtained. The iron producing centers were very small and fewer in number than in England.

In colonial days most of the nails used and all of the nail stock were imported from the European countries, principally England or at any rate under the direction of the English Crown.

In the year 1731 there was officially reported to be "One slitting mill and one manufacture for nails" in Massachusetts. In 1750 there were only four slitting mills in the same colony. All of these mills led a rather uncertain existence on account of the English jurisdiction over the iron production in reference to

the manufacture of nails. It was not until during the first quarter of the Nineteenth Century that the iron industry in America was in any but the most primitive condition.

Before the American Revolutionary War, England had imposed such restrictions on the manufacture of iron that very few furnaces withstood the heavy taxes imposed on them and their success was looked upon with disfavor by the English iron masters. During the war and immediately thereafter, the manufacture of iron was undertaken most earnestly and it thrived henceforth. Slitting mills and nail shops were started generally throughout the States.

(e) ECONOMIC VALUE OF THE NAIL INDUSTRY TO THE COLONIES. In the very early days of the American Colonies, it is doubtful if any nails were made at all on this side of the Atlantic. There were no iron works of any consequence so all the material would have had to be imported for the work. Just when nails were first forged in America is not known, but, in the latter days of the Colonies just previous to the Revolutionary War, it is known that considerable iron was turned into nails by hand - not with a view of exporting any, but for Colonial consumption only.

As to the economic value of nail making to the Colonies, the trade may have furnished a livelihood for a few individuals; but, as far as the Colonies themselves

were concerned, it was nil and was made so by the conditions imposed by England at the instance of the English nail master.

After the Revolutionary War, the chimney corner industry of nail making was undertaken by the farmers in order to have work for the long winter evenings; but, in 1795, it received a set-back on account of the advent of machine made nails. After this time, American hand-forged nails, always a scarce article, were a thing of the past. In England, the hand-forged nails thrived for a hundred years longer until they were finally driven out of there by the machine made nail, which came into favor sometime between 1885 and 1890.

(f) OUTPUT OF ONE NAILER. Very little is recorded which gives an idea of the daily output of a single nail maker. A story is related of an English nailer, presumedly operating a hearth near Birmingham, England, who made a wager that he could forge 17,000 twenty-penny (20) wrought iron nails per week, for two consecutive weeks, working ten hours a day. It is stated that he easily won the wager. He had produced 680 pounds of nails in 140 hours, or about five pounds per hour. A modern nail machine on 20d nails will produce about 325 pounds of nails per hour, or a gain of 320 pounds per hour over hand forging.

(g) TYPE OF HAMMER USED BY NAILERS. The nailers used a special hammer with a peculiarly shaped head for

making hand wrought nails. The face on one end of the head was slightly beveled toward the handle and this was used to taper the nail shank as the nail rod was held on the anvil. The other end of the hammer head was cylindrical, of the usual ball face, and was used to form the head in the counterbore of the nailer's plate. The hammer head weighed about two pounds.

(h) PHYSICAL ENERGY REQUIRED TO MAKE NAILS. In making each nail, the nailer performed a cycle of operations about as follows. The nail rod was first heated in the forge, and, to do this, the nailer had to operate his own bellows: after being heated, the nail rod was transferred to the anvil, where the end was drawn down to the proper taper with a few sharp blows of the hammer: the required length of rod was now cut off to gage on a chisel, held on the anvil, and then, if still hot enough, the cut and tapered piece of nail rod was dropped point first into a "bore" or tapered hole in the anvil, leaving an amount projecting beyond the bore: this heated and projecting end of the rod was now hammered into the proper shaped counterbore, thereby forming the head of the nail: the finished nail was now driven out of the bore and the cycle of operations repeated. Raised or ornamental heads were formed with an oliver.

It has been estimated by one writer that to make one 20d nail, required a total of about twenty-five

strokes of a two pound hammer raised to an average height of three feet per stroke. To make one thousand nails at that rate would require an expenditure of energy equal to 150,000 foot-pounds of work extended over a period of time equal to about eight hours, while a modern 20d nail machine would require an expenditure of 915,000 foot-pounds of work, but would complete the one thousand nails in about six minutes.

II. THE WIRE NAIL.

(a) HISTORY OF THE WIRE NAIL. Like that of its fore-runner, the wrought nail, the origin of the wire nail is clothed in obscurity to a considerable degree. France is, without doubt, the birthplace of the wire nail, and, because of its birthplace, it was originally known as the "French" nail. As such, it is occasionally referred to even now.

As early as 1750, nails were made by hand in France from cylindrical wire and in this way differed from the original hand wrought nail, which was made from a square or rectangular wrought iron rod. The wire nail had a straight shank, while the wrought nail was tapering. The wire used in the making of the French nails was wrought iron, or some other metal, but not the steel with which we of today are so familiar. The art of making wire by hammering metal into long, cylindrical rods had long been known, for samples of brass wire have been found in the pyramids of Egypt. The Germans started to draw wire about the Fourteenth Century. No attempt was made to adapt the drawing of wire to any other commercial enterprise, so the art remained dormant. It is not surprising that some wire did get into France, even though no attempt was made on the part of Germany to export it.

For a considerable space of timeFrance was the sole producer of wire nails, but they were made of very light wire and only for home consumption. No attempt was made to commercialize this nail altho Belgium and later Germany started the manufacture of wire nails, but on a very small scale and by hand at that.

(b) EARLY METHODS OF MAKING. The method employed to make wire nails by hand was much more simple than that used to make hand forged nails. The wire was first cut into the required lengths, and then one end of each was pointed on an anvil. The pointed piece of wire was then clamped in a vise with a portion of the unsharpened end projecting above the vise jaws, which, under a few sharp blows of a hammer, formed the head of the nail. The simplicity of the wire nail is due entirely to its having a straight shank instead of a tapered one like that of the forged nail.

Difficulty was encountered in the making of these by hand and this difficulty continued long after machines were employed. It was due to the fact that the available wire did not readily respond to the attempt to form the head, but the remedy came after the manufacture of steel became more flexible as a result of a better understanding of the chemistry of steel making. The failure of the Bessemer process of steel making to measure up to the expectations of the inventor was due to this same lack of knowledge. This fact delayed the de-

velopment of the steel industry several years and, consequently, delayed the development of the wire nail industry.

(c) ITS INTRODUCTION INTO AMERICA. In the middle of the Nineteenth Century, William Hassel, Sr. and Thomas Norton of New York were engaged in the business of building machinery. About 1851 or 1852, they built a machine to manufacture dowel and hinge pins from wire, thus being the first in America to make wire nails. This business of wire hinge pins did not prosper, so, in 1857, Mr. Hassel bought the plant. The machines were shortly put to use in the manufacture of French wire nails of small size to supply the needs of a German picture-frame maker, who could not import enough wire nails to supply his shop. He preferred the wire nails because they did not split the wood, from which the frames were made; hence, the arrangement with Hassel for the manufacture of nails.

Because of the difficulty of obtaining satisfactory wire, the business lagged though it continued until about 1877. Hassel either lacked aggressiveness or did not realize the possibilities of wire nails; at any rate, no attempt was made to increase their use by him.

In 1875, Father Gobble, a Catholic priest, came from Germany to Covington, Ky., and there, associated with Michael Baaches, started the Covington Wire Nail Works for the manufacture of wire nails. Covington was

chosen, because at that time it was an important iron producing center. This effort, limited as it now seems, was the first concerted attempt to introduce wire nails into America for general use. The next year, the company exhibited at the Centennial Exposition at Philadelphia, which did much to familiarize the American Public with the possibilities of wire nails.

The Covington factory, after a time, was a success and is still making nails, although the name and the geographical location have been changed several times. Thus, the wire nail was introduced into America from Europe, but the Americans were slow to adopt it generally.

(d) ITS RECEPTION BY THE TRADE. The trade dealing in nails did not welcome the newcomer in the field of commerce and from no quarter did the manufacturers of wire nails in Covington receive any encouragement whatever. They early realized that they had encountered, and must overcome, a prejudice against the smooth shank of the wire nail. Every one was used to the more rough edge of the cut nail, which, by this time, had superseded the hand-forged nail, in America at least. For the purpose of overcoming this prejudice against the wire nail because of its smooth shank, barbed nails were first made and they succeeded, in a remarkable degree, in overcoming the objections. The nails were barbed then, as now, by running the wire - before the nail was made - between two marred grooved rollers, which simply roughed the wire.

Barbing the wire increased the holding power considerably over the smooth shank and formed a stepping stone for the successful application of the wire nail in America.

(e) ASCENDANCY OVER THE CUT NAIL. The hand-forged nail of the Eighteenth Century was superseded in the early half of the next century by the advent of a nail cut, by machine, from wrought iron plate. By 1840, both forged and cut nails were commonly used, but in America the machine nail always took the lead. After the advent of the first nail machines, their product, the cut nail, held first place until the last quarter of the Nineteenth Century when the wire nail began to make its presence felt. In 1888, plate cut nails first noticed the inroads being made in their business by the wire nails. In this year, one-fifth of the total nail output was of wire. By the year 1895, three-quarters of the total output of nails was of wire.

For some time the use of the latter type of nail was regarded as harboring trouble for the user. There are still a few adherents to this belief, but their numbers are fast dwindling. The use of the wire nail in engineering enterprises and in commerce is one of undisputed importance.

Because it is made of wire and because, in the process of making wire, the rods are pickled in a solution

of dilute sulphuric acid to remove the scale, the objection has been raised that the wire nail will not weather, but will be eaten off by the acid. This assumption is not just right.

As a preliminary operation in the manufacture of wire, the rods, after they come from the rolling mill, are pickled in a sulphuric acid bath to remove the scale. From the acid, they are plunged into a bath of clear water to stop the action and remove the acid from the rods. From this water bath, the rods are placed on a rack to "sull". The sull is a dark green oxide which forms on the warm and damp, but clean, iron surface of the rods. After sulling sufficiently in a fine spray of water, the rods are immersed in a hot, milky, lime water bath; then, with the sull and lime still adhering to their surface, the rods are placed in a dry house to bake at a temperature ranging from to 300 to 400 degrees Fahrenheit. After this, the rods are ready to draw.

The sull and lime coating, along with either a heavy grease or hard soap through which the rods pass previously to entering the drawing die, forms a lubricant which remains on the wire for several drafts. A better material, for a lime substitute, has never been found, but the lime so used must be free from grit. If the baking in the dryhouse is done at too low a temperature, the wire will be "acid brittle" and break too often to permit economical drawing. Then, the wire must be rebaked.

It is the baking, and not the lime as is generally supposed, that kills the acid. We are assured of wire nails being made of acid-killed wire if for no other reason than that no wire can be drawn successfully, from which the acid has not been eliminated by baking.

Polished steel wire nails, the ones usually encountered, do rust rapidly when exposed to damp air. The rusting occurs, not because acid is used in the manufacture of the wire but because the nails are of steel. Common soft steel is characterized by excessive rusting under some conditions, which is not true of wrought iron.

The Bessemer process of steel manufacture, invented in 1855, increased the output of steel wire, which, on account of its being cheaper, gradually crowded the wrought iron off the market. The greatest impetus came in 1878, when the Bessemer process was still further perfected by the Thomas-Gilcrist method of using a basic lining - thereby producing the basic Bessemer steel.

This latter invention was brought out three years after the establishment of the manufacture of wire nails in America, so, naturally, the manufacture of wire nails increased with the increase in production of Bessemer steel wire.

The Thomas-Gilcrist or basic Bessemer process of steel purification is not applicable to the general run of iron ores found in the United States. For that reason, it has been discarded in this country for the acid Bessemer process and the basic open hearth pro-

cess, both admirably adapted to the American ores.

(f) STANDARD SIZES OF COMMON WIRE NAILS. The manufacturers and users of wire nails have long since agreed to certain standard dimensions of wire nails and the following table gives the sizes standard for common nails only. The various styles of wire nails have been standardized in like manner. The weights given in the table are those used by the largest manufacturers of wire nails, but are subject to slight variation , unavoidable thru the adjustment of the machines. The variation will not amount to over 1/4 of 1%.

TABLE 1.

NAIL SIZE	HEAD DIAM.	LENGTH INCHES	WIRE GAGE	APPROX. NO.1 LB	WEIGHT PER 1000
2d	5/32	1	15	876	1.15
3d	3/16	1-1/4	14	568	1.8
4d	1/4	1-1/2	12-1/2	316	3.3
5d	1/4	1-3/4	12-1/2	271	3.7
6d		2	11-1/2	181	5.5
7d		2-1/4	11-1/2	161	6.2
8d	9/32	2-1/2	10-1/4	106	9.4
9d	9/32	2-3/4	10-1/4	96	10.4
10d	5/16	3	9	69	14.5
12d	5/16	3-1/4	9	63	15.9
16d	11/32	3-1/2	8	49	20.5
20d	13/32	4	6	31	32.3
30d	7/16	4-1/2	5	24	41.6
40d	15/32	5	4	18	55.6
50d	1/2	5-1/2	3	14	71.5
60d	17/32	6	2	11	91.0

The wire gage referred to is the one now known as the "Steel Wire Gage"(formerly known as the "Washburn and Moen Gage") and in this country generally used by all steel manufacturers tho under various names. Upon

the recommendation of the Bureau of Standards, Washington, D.C., a number of the important steel wire makers and consumers agreed to the designation of this gage as the "Steel Wire Gage". Thus it has official sanction, but no legal standing by any act of Congress.

(g) KIND OF STEEL USED. When wire nails were first being made by hand, the only ferrous metal wire known was that made of wrought iron. This continued to be the case for some time after the advent of wire nail machines in this country, which was also about the time of the Thomas-Gilcrist improvement in the manufacture of Bessemer steel. This improvement gave such an impetus to the manufacture of mild steel that wrought iron could not long compete in price and was soon to disappear so far as the manufacture of wire was concerned.

Shortly after 1880, several manufacturers were in the business of making wire nails. They early realized the change that was about to take place by substituting steel wire for wrought iron wire for making nails. But the decided preference for wrought iron wire, adhered to not alone by their customers but their own nail makers as well, was hard for the manufacturers to overcome because of the difficulty encountered in making the nail head with Bessemer steel. Swedes iron seems to have been the favorite with all. The H. P. Nail Company of Cleveland, Ohio, which is at present (1921) one of the largest nail mills in the United States, was the first

to succeed in using Bessemer steel wire for nails. Their example was soon followed by all the other manufacturers of wire nails - not from choice, but from necessity.

The first United States decennial census to show a decrease in the wrought iron manufactured was that of 1890, thirty-five years after Bessemer's invention.

Wire nails are now made, for the most part, of Bessemer steel wire, unless the nails are to conform to some special requirement of the user which cannot be complied with by using Bessemer stock; such, for example, as the heads of 1/2" and 5/8" in diameter formed on roofing nails. In forming these large heads, the Bessemer steel splits around the circumference of the heads. These specifications usually require the use of some slightly better grade of steel. Either the basic open hearth or the duplex steel is used. The duplex steel refers to a combination of the acid Bessemer and the basic open hearth processes. The advantage of the duplex process of steel manufacture lies in the increased tonnage which it produces, in a given time, over that of the open hearth process. The product is similar to and equal in quality to the steel produced by the open hearth process alone.

III. EARLY NAIL MAKING MACHINES.

(a) THE SLITTING MILL. When nail rods were first produced, from which hand forged nails were made, they were hammered to size by water power. In 1617, Sir D. Bulmer of England devised a machine for cutting nail rods, but, aside from devising a simple mechanism, he did nothing more with it. In 1784, Henry Cort of England was granted a patent for a rolling mill for producing bars in grooved rollers. This method was slow and the practice, except for the finest grades of nails, was discarded for the cheaper method of the slitting mill. In this mill, wrought iron plate (already rolled to the required thickness) was introduced between gangs of opposing rolls, consisting of hard crucible steel discs, so spaced on two parallel power driven shafts that the resulting slit bars would be of the sizes required by the nailers. These bars from the slitting mill bore the characteristic rough sheared edge which was so much desired by the nailers, on account of the popular belief that the holding power of a nail was thus considerably increased.

The slitting mill is a subject to which there is attached considerable uncertainty as to its origin, altho generally considered as having originated in one of two countries - either Holland or Sweden. From there

the idea was brought to England by an English mechanic by the name of Foley, who purposely visited the foreign iron works where slitting mills were in successful operation. There he gained admission to the works by posing as a wandering musician. He obtained the coveted information regarding the slitting mill and returned to England, where he put the idea into practice. His stolen secret, whether of Dutch or Swedish origin, was the means of increasing to a very considerable degree the production of nail making material - not alone in England, but in the United States as well.

(b) PLATE NAIL MACHINE. The invention of nail making machines, as well as their successful evolution, is due to American ingenuity and in no country has the development of the nail machine kept pace with that of the American builders.

Very little hand forging of nails was ever carried on in this country. For this, we have England to thank, altho her attitude in the matter of Colonial nail making was not prompted by beneficent intentions. Before the Revolutionary War, England would allow only a small amount of nails to be made on this side of the Atlantic - all because of the short-sightedness of the English nail masters, who prevailed upon the government to place such unjust restrictions upon the business that it never had so much as a good start in any of the Colonies.

Immediately after the Revolutionary War, a great number of hand forged nail shops opened up and the American inventor started to build machines to take the drudgery out of hand nail making. Notable among the inventions patented in the early days is that of Jacob Perkins, shortly before 1795. While it was not a success in all particulars, it made the hand forging of nails by the Massachusetts farmers an unprofitable undertaking.

On March 23, 1795, a patent was issued to Josiah Pierson of New York on what was the first really successful machine so far invented. This style of machine was in use at least until 1830.

Nearly all of the early patents were issued to residents of Massachusetts and Connecticut, which states, for some time to come, were to be the center of the nail industry.

The characteristic feature of the old, hand forged nails was the long and comparatively tapering shank and it is to be expected that this main feature would obtain in the product of the first machines to make cut nails. Such was the case.

The first inventor to obtain an American patent on a nail machine was Ezekiel Reed of Bridgewater, Mass., in 1786. A little later, in 1790, an English patent for a cut nail machine was issued to an English inventor by the name of John Clifford. These two machines were fundamentally alike. The nail stock used was wrought

iron plate, furnished by the rolling mills in sheets cut about one foot long and of a width corresponding to the length of the nail to be cut. The taper of the longer nails was obtained by rolling the plates to a wedge-shaped section. The taper of the smaller nails was obtained by cutting the plate obliquely and turning it over each time a nail was cut.

The nail stock was heated to a very dull red, then fed by hand into the machine. The nail was first sheared off and the blank dropped into a gripper, which held the nail fast until a heading die advanced and formed the head. The finished nail was dropped down a chute and the cycle repeated.

Machines of this type were in operation as late as 1860 in the plant of the East Jersey Iron Manufacturing Company, Boonton, N.J.

(c) FRENCH WIRE NAIL MACHINE. The first wire nail machine to be imported into this country came from France about the year 1875. It was imported by the American Wire & Screw Nail Company, Covington, Ky. This company had started the same year to make wire nails by hand. A few machines had been made in this country for the manufacture of wire nails before this time.

In this French machine, the head of the nail was formed by a heading die, carried on a crosshead or hammer. The crosshead was actuated by a long, flat, vertical wood leaf spring, the top end of which was secured in the

ceiling, while the bottom end projected down into the machine and engaged the crosshead. A cam on the main shaft of the machine sprung the wood board, the release of which produced the blow of the heading hammer which formed the nail head. The wire was then fed into the machine the proper length, cut off and pointed in the same operation. A number of this spring board type of wire nail machines are still in operation in the United States. All types of wire nail machines make noise, but, of all types, the French spring board machines are the noisiest.

(d) GERMAN WIRE NAIL MACHINE. In the German nail machine, the wood spring is present also, as it is in nearly all the early European models. The wire is fed into the machine intermittingly from a coil. The nail head is formed by a heading die carried in a crosshead, the latter being operated by a spring. The heading blow is quite as sharp as it is on the French machine and just as effective. One nail is made for each revolution of the machine. This type of machine is no more desirable from an operating standpoint than the cumbersome French machine.

Several types of machines of German invention are still seen in operation in American nail mills and their good features have been adopted considerably in other nail machines. The spring type of machine is used now to a great extent for making large headed nails, although

the "National" machine will make nails with heads just as heavy.

(e) FUNDAMENTAL FEATURES OF ALL WIRE NAIL MACHINES. In a general way, all wire nail making machines, while of widely varying types and with parts variously arranged, are primarily of one class - a combined power hammer and shear. The hammer forms the head on one end of the nail, after which the shearing operation points the other end, making one complete nail for each revolution of the machine.

The wire, from which the nails are made, is gripped by some device on the reciprocating feed table of the machine and fed into this machine the proper distance by advancing the feed table. The wire first passes between a pair of opposing dies, each having a barbed groove along the centerline of the contact faces. These are the pinch dies. The wire next passes between two more opposing dies, ground "V" shaped on their contact edges. These are the cutting dies.

At the instant the feed table stops, the cutting dies meet, cut the wire and immediately re-open. In the meantime, the pinch dies with the barbed grooves grip the wire back of the cutting dies, leaving, however, sufficient wire protruding to form the head of the nail. This is done by the blow on the end of the wire from the now advancing hammer. The head is formed in the counterbore of the pinch dies, which act as the anvil.

During the heading operation the feed table recedes to get a new grip on the incoming wire, which, when released by the pinch dies and with the nail head on the end, is moved along by the feed table the desired nail length. The nail is now ready to be cutoff and pointed by one operation of the cutting dies. See Figure II.

The method of making wire nails has been standardized to a considerable extent. Nail sizes, both in gage of wire and length of nail, have been made uniform or practically so by the nail manufacturers, and the builders of nail machines have standardized their machines to correspond to these nail sizes.

IV. AMERICAN WIRE NAIL MACHINES.

(a) EARLY AMERICAN INVENTIONS. Wire nails had been manufactured in New York at odd times to fill special orders since 1857. In 1875 their manufacture was permanently started in the United States at Covington, Ky. The field thus opened up for machinery to make wire nails was not at all attractive to inventors for at least seven years more, according to the records of the patent office. It must be remembered, in this connection, that the trade in cut nails was not vigorously crowded by the wire nails until about 1888 on account of the difficulty of obtaining wire to suitably form the nail heads.

Altho several firms were in the wire nail business as early as 1880, the machines used were few in number and all imported. In 1882, a patent was issued to William Taylor covering a wire nail machine - the first wire nail machine to be mentioned in the United States' patent office records. All other nail machine patents had been issued covering machines to make nails from nail plate or from nail rods, but wire nails were not considered. The claims in the Taylor patent did not cover an entirely new machine, but rather improvements

to be used singly, or in combination, on existing types of machines. This can be said of most of the patents that have been taken out on wire nail machines. The nail to be manufactured was comparatively new in this country, but the machines that could be used for its manufacture were adapted from the existing types, used to make nails from nail rods and for which patents had already been issued. There is no line of demarkation where the patents on nail machines are distinctively for wire nails, but, in the Taylor patent and in those issued thereafter, there is that careful wording to claim both the cut and wire nail combination.

(b) TREND OF INVENTIONS. The Taylor patent claimed a reciprocating feed table, in combination with a chisel grip, to advance the wire or nail rod into the machine and a set of marred rolls to barb the wire during the return stroke of the feed table - made while the wire was being held in the pinch dies during the heading operation. This combination is in extended use today.

This patent also claims a heading die backed by four compression springs in combination with a cam on the main shaft to compress the springs, the release of which formed the nail head. This feature was not a success, but it is interesting to note that the spring device of forming the head on nails was still in use at the time this patent was issued, having had its origin in France where the single leaf wood spring was used, fastened to the ceiling. The American adaptation of this was a vertical steel leaf spring

fastened to the floor. This feature was copied by the Germans.

In 1884, a patent was issued to George M. Cooper for a wire nail machine. He claimed an adjustable die, ground "V" shaped, to pinch off the wire and to form the point of the nail at the same time. This feature is in use today on practically all machines making wire nails. His machine is notable in that he had discarded the spring to form the head and claimed, mounted on a rockshaft below the machine bed, a header which was actuated by a pitman from the main shaft. This header was not a success in itself, but it paved the way for improvements to come later.

Shortly after the Cooper patent, one was issued to S. Loring who claimed a toggle joint heading mechanism actuated by a pitman from the main shaft of the machine. Modifications of this header were patented in the early nineties by Michael Baaches, some of whose machines are still in use.

In 1885, a patent was issued to William Hassel, a son of the first American manufacturer of wire nails, covering a nail machine having the heading die carried on a crosshead which was operated by a pitman, direct-connected to a crank formed on the main shaft of the machine. This was the most successful machine so far devised and a great many were built in sizes ranging to make nails from 2d to 60d. The machines were made by

M. M. Smith of Brooklyn, N. Y., and were known as the "Brooklyn" nail machine. The direct-connected crosshead permitted increased speeds. The pinch and cutting dies were operated, as in previous machines, on levers actuated by cams mounted on the main shaft. The "Brooklyn" machine is a common sight in wire nail mills of today.

In 1892, a patent was issued to A. Alexander covering a nail machine in which gears were substituted for the cams, which operated the cut levers on most of the previously patented designs. This machine was a "double header"; that is, two sets of heading and cutting dies were used making two nails at a time, in place of the usual one. The design was not good. Provision for adjusting the dies, which is a necessary feature of every good nail machine, was lacking. The machine was fairly well received and a number were built, some of which are still in use. They are known as the "Alexander" machine.

A few years later, the National Machinery Company, Tiffin, Ohio, developed what was then known as the "Tiffin" nail machine - now called the "National". The distinguishing feature of this machine was the elimination of gears and cams to operate the cut levers. Besides the main crank to do the heading, two extra cranks are turned in the main shaft from which, by means of radius links connecting to the cut levers, the cutting dies are actuated. The pinch lever was, and is in the later machines, operated from a single cam. These machines are still manufactured by the

same company, in sizes ranging to cut from 2d to 60d nails.

When the "National" nail machines were first put on the market, they represented the best designed machines for making wire nails. They have stood the test of time and proved that they may be fully depended upon. Thus, a more detailed description of their operation is justified.

Figure I shows the complete "National" nail machine No. 2, the size used to make 10d nails. The same general design is followed in all machines of this make. The wire is fed from a coil (not shown) at the right side of the photograph and advances between the straightening rolls on the feed table, traveling toward the left. Figure II clearly shows the wire, the nail head formed, protruding beyond the pinch dies and ready to be cut off by the pincher like action of the cutter dies. Figure III shows a view of the pivotal point of the cut levers, taken from the side opposite that shown in Figure II. The relation between the upper and lower cut levers is clearly shown, as is also the method of securing the cutter die holders. The ease of adjustment of all dies is also shown. Figure IV shows the connection of the cut levers to the cutter cranks on the main shaft by means of the bronze radius links in the immediate foreground.

(c) LATER TYPES OF NAIL MACHINES. Within the last few years, two wire nail machines have been developed; one known as the "Universal" and the other as the "Ryerson-

Glader", named in the order of their appearance on the market.

The "Universal" machine is built by Sleeper & Hartley, Inc., Worcester, Mass., and was first offered to the machinery trade in several sizes in the year 1917. The machine contains no cams, operates a single crank, and points and heads at the same time on two different nail blanks held in a carrier.

The "Ryerson-Glader" machine, shown on Figure V, was designed by William Glader of Chicago and is distributed by the Joseph T. Ryerson Company of Chicago. In form it closely resembles the "Alexander" machine, except that it is for making a single nail. This line of nail machines, in several sizes, was put on the market in 1920.

These machines just enumerated, with a scattering of foreign made machines, principally of German origin, form the bulk of the machines used in the past and at present in the majority of nail mills of this country.

(d) PERFORMANCE OF VARIOUS MACHINES. From the very character of the work which a wire nail machine is called upon to perform, one would almost say that speed was out of the question because of the constant hammering of one part against another while the machine is in operation. In a nail mill, the nail machines are ordinarily expected to operate at 98% efficiency expressed on the basis of the ratio of $\frac{\text{actual output}}{\text{theoretical output}}$. A nail machine which will not do that well is not worth running. Machines are made which

will do it and in purchasing equipment for nail mills this point should be considered.

During one revolution of a nail machine shaft, there are three points of maximum strain. These are

1st. The Pinching Operation
2d. The Heading Operation
3d. The Cutting Operation

and all of these are in the nature of a shock to the machine parts.

The radius link connections used in the "National" to actuate the cut levers make these machines direct connected and easily adjusted to compensate for wear. In the case of machines using cams for cutting, the wear is not easily taken up, and, unless it is, the machine must run more slowly.

In the "National" machines, the main shafts have three cranks turned in them, while most of the other types have only one - that used for actuating the header. In case the main shaft of a "National" breaks, the cost of replacement is perhaps higher than that of any other type; but, on the other hand, the "National" link connection is less expensive to make than cams would be. For the same sized nail, the "National" will withstand a higher speed than many and will hold up longer than most machines.

In this connection and in fairness to the "Universal" and "Ryerson-Glader" types, it can be stated

that since these machines have been on the market such a relatively short time a comparison between them and machines which have been in operation for several years is impossible.

In machines having gears, the work of cutting the nails always comes on the same few gear teeth which soon results in excessive wear of these parts.

In general, it is true that the more simply a nail machine can be constructed, the better. Parts on all nail machines need replacing at times, and, in buying new machines, those having parts most easily reproduced should be given preference - all other things being equal.

(e) OPERATING DIFFICULTIES ENCOUNTERED. The ordinary nail machine has about six main parts that are subject to strains causing wear or breakage and the replacement of these parts is an important item of expense in a large nail mill. It is an amount that increases rapidly, unless a close watch of the machines is kept to discover, if possible, any weak part liable to result in a break.

The parts that are subject to breaks from strain are the bed, the cut and pinch levers, the shaft, the flywheel and the feed table. A breakdown of the flywheel is most dangerous to the operator and from a safety standpoint should be carefully avoided.

(f) MATERIAL BEST ADAPTED FOR PRINCIPAL MACHINE PARTS. The beds of practically all types of nail machines have been and still are being made of cast iron by the

builders. It is evident to the observer in a nail mill that if the beds were made of steel casting not only would the breaks there be reduced, but also the accompanying breaks on other parts would be lessened. The item of first cost enters here. If the point at issue is a new bed for an existing machine, there can be no question of the advisability of using steel casting; but, if the purchase of considerable new equipment is contemplated, the item of first cost of steel casting beds versus cast iron beds must be weighed carefully against the probable repair item. If initial cost does not have to be seriously considered, there is no doubt of the advisability of using steel casting.

The shafts of nail machines break from being crystallized, due to the continued shocks. From the record kept in a large nail mill, it is learned that the best steel to use on shafts is a 3-1/2 % nickel steel, heat treated. Considerable use is being made now of low nickel chrome steel, heat treated. The price is a little lower than for nickel alone and the quality is said to be about the same as the 3-1/2% nickel, but the results so far do not justify the change. In most cases, the 3-1/2% nickel steel shaft has the advantage of several years of service in its favor.

The cut levers and the pinch levers of a nail machine are parts having an oscillating motion and, since they are levers with unequal arms, they are not

balanced. The lighter they can be made, with equal assurance against breakage, the better. This argues for steel casting, as indeed this is the material they should be made of.

The feed table is a reciprocating piece in which strength is important and this also should be made of steel casting.

The fly wheel is subject to severe shocks, if anything goes wrong with the adjustment of the pinch dies while the machine is in operation. Nothing but steel casting should be considered for this part.

V. AMERICAN WIRE NAIL INDUSTRY.

(a) THE FIRST WIRE NAIL FACTORY. In the year 1875, Rev. Joseph Gobbles, a Catholic clergyman, came to Covington, Ky., from Germany and started the manufacture of wire nails by hand. Later in the same year, Father Gobbles, associated with Michael Baaches, imported a French wire nail machine and in December of 1875 formed a stock company under the name of The American Steel Wire & Screw Nail Company.

It is interesting to follow the fortunes of this first wire nail company and to learn that it still lives. A few years after the stock company was formed, the name was changed to The American Wire Nail Company. Later, the works were moved to Anderson, Ind., where the company was absorbed in 1898 by The American Steel & Wire Company. This latter company is a subsidiary of the United States Steel corporation and the nail mill at Anderson, Ind., is still (1921) operated as part of the Anderson Works of the American Steel & Wire Company.

(b) GROWTH OF THE NAIL BUSINESS. The wire nail business in America received its first impetus in 1876, due to the Centennial Exposition at Philadelphia at which the American Wire & Screw Nail Company, the infant wire

nail manufacturers of Covington, Ky., placed an exhibit of their products and won the first prize over French, German and Belgian competition. This presented the wire nail to the American public in a most forcible manner and aided the Covington factory considerably, altho America was slow to adopt the wire nail for her needs.

By the year 1888, wire nails had obtained a strong foothold in the trade so that for the first time the plate nails felt the competition. One-fifth of the total tonnage of nails produced that year was made of wire. Growing steadily year by year, the wire nail business gained the advantage, which it has never lost. In 1895, seventy-five per cent of the total tonnage of nails produced was wire. Shortly after this, the wire nail had practically the entire field and the cut nail represented only a very small fraction of the total tonnage produced.

The wire nail still holds the advantage gained in the early nineties because of the lower cost of producing nails from steel wire. This advantage in trade was gained only by cutting the price of wire nails to the minimum and they have sold as low as eighty to ninety cents, base, per 100# keg.

(c) ECONOMIC VALUE IN ITS RELATION TO WIRE BUSINESS. The manufacture of wire nails is closely related to and dependent upon the manufacture of wire, which is raw nail material. There is an economic reason for this rather close relationship between wire drawing and nail making.

In the process of drawing wire, a day's run will result in the production of a small percentage of comparatively short lengths of wire which have a limited sphere of usefulness. These short lengths ("shorts", as they are called in the wire nail mill) would ordinarily be classified as scrap wire. They occur through no fault in the manufacture of the steel itself; hence, being good steel wire, they can be profitably cut up into nails and sold at the market price of nails instead of being disposed of at the market price of scrap wire.

For this reason, nail making is at least a side line of most wire drawing plants, where from one to ten wire nail machines are kept busy cutting nails from the mill rejections as an economical measure.

However, the extent of nail making is not dependent upon wire mill rejections. Quite the contrary! The bulk of wire nails is made from wire drawn for the specific purpose of nail making.

The manufacture of wire nails, as an industry, started in America in the year 1875 with the establishment of the Covington factory. Very little capital was invested because the nails were made by hand of wire produced in Covington, but outside the nail factory. Up to 1880, about twenty-five firms had engaged in the manufacture of nails. By 1895, the wire drawing and wire nail making had become centralized to the point where the wire nail market was controlled by six to eight large companies producing nail wire in their own drawing plants and rod mills.

(d) THE NAIL COMBINE AND ITS INFLUENCE. In June, 1895, the principal nail making companies in the United States formed a combine called "The Wire Nail Association" under the leadership of John H. Parks, who had gained considerable experience in forming combines in the days when monopolies, now considered illegal, were tolerated. The nail firms directly responsible for the Association were

The American Wire Nail Co.
The Indiana Wire Fence Co.
The Consolidated Steel & Wire Co.
The Illinois Nail Co.
The Superior Barbed Wire Co.
The Judson Manufacturing Co.
The Brooklyn Wire Nail Co.

The members were equipped with their own rod and wire mills to supply wire for nail manufacture. For his work in organizing and managing the Association, Mr. Parks received one cent for each keg of nails made by the Association, which amount was paid by the members. In addition to this amount, the members were assessed to build up a fund for the purchase of other mills and to provide working capital. On the payment of money from this fund, several companies, manufacturing nail making machines, were known to break contracts they had made to sell machines to nail makers outside the Association. This high-handed method effectually curtailed expansion in the nail making business outside the Association for a considerable length of time.

This Association was shortly followed by one formed by the manufacturers of cut nails and another by the Canadian manufacturers of nails. These three succeeded in keeping all European nails out of the country during the life of the Wire Nail Association, with the exception of one cargo of Belgian nails said to have been landed in New York.

In 1892, a list price of nails was published using the 60d spikes as the base, with a graduated extra price over base for the succeeding smaller sizes. For 2d nails, the extra was $1.60 above base. The base price from 1892 to 1895 was below the cost price of raw material for nails, not to mention the cost of manufacture and the price of the keg.

However, through the efforts of the Association, the base price and extras on nails were adjusted so that each size nail was sold to pay for its own manufacture. Prices quoted were all f.o.b. Pittsburgh, with freight from Pittsburgh to destination added, regardless of the place of production. This arrangement holds good to the present time.

VI. THE MANUFACTURE OF COMMON WIRE NAILS.

(a) THE OPERATING ORGANIZATION OF A NAIL MILL.

In addition to the executive department of the plant, the nail department has an operating organization charged with the proper and economical operation of the mill. The operating head of the nail mill proper is the foreman. His schedule of operation is sent from the general office and is based upon a consideration of orders received and the condition of the stock of finished nails on hand. He is charged with turning out the required tonnage, ordering the necessary material and keeping the employment department informed of the number of men required to keep the mill operating to schedule.

In the nail mill, the total number of machines is divided into groups called "sets", each set having twelve to fourteen machines in direct charge of an operator who is responsible for the operating adjustment of the machines and the production of such nails as will meet the standard specifications. Each operator has one or more helpers, depending upon the tonnage of the set, to handle the wire and put the finished nails into trucks for transportation to the Cleaning Department.

An inspector is employed, charged with the rejection of improperly made nails from whatever cause. It is his duty to see that the nails have standard sized heads, correctly formed, that the nails are of proper length and gage, and that the points are well made. Upon his efficiency, depends largely the reputation of the mill for good or poor nails.

A scale-man is official weigher of all nails produced and a record is kept by him of the weight of each size of nails made in each set. The weight is taken just as the nails are entering the cleaning department and this record forms the basis of payment to all tonnage workers.

The cleaning and packing room is in charge of a head packer, whose duty it is to see that the nails are properly cleaned, to watch for bent nails and to see to the proper packing and weighing of the nails.

The warehouse is in charge of a sub-foreman, who sees that the kegs are properly stored or sent out on orders and that the orders are correctly filled and checked before shipment.

Repair work about the machines is made by a special crew of men, directly responsible to the mill foreman. Repair work about the mill drives is made by the plant millwright.

The die room is in charge of a head die maker, with the required helpers. Dies are issued to operators by the head die maker only as they are needed.

This forms the skeleton of the usual operating organization of a nail mill and reference to Plates I to V, inclusive, will aid in a clear understanding of this organization.

(b) TRADE DEMANDS FOR COMMON NAILS. It is a well known fact that, in the general run of nails sold, there are certain sizes customarily used; while other sizes, though standard, are used less frequently. The demands follow the custom of builders in their use of nails. The lumber used ordinarily increases in size by 1" increments, while common nails are standard with 1/4" increments up to the 16d size and in 1/2" increments above that to the 60d size. The sizes most commonly used are 4d, 6d, 8d, 10d, 20d, 40d, and 60d. The other sizes are used, but not so generally. Nails are also sometimes ordered as special of either larger or smaller gage than that which is standard for a given length.

A great number of the nails exported have checkered heads. This style of head is standard in Europe. All the wire nails made by William Hassel about 1857 had checkered heads, following the European custom. The smooth head nail is a result of the American custom of reducing costs wherever possible. In this case, the crosshatching of the header dies was eliminated. Just when the use of a smooth rather than a checkered head became a custom in America is not known.

(c) ORDINARY RANGE OF NAIL MACHINE SIZES.

The manufacturers of nail machines still follow more or less closely the same range of sizes that has been in vogue since the days of the first "Brooklyn" machine. The standard sizes of common nails are given on page 19.

The following tables give the range of the four principal makes of nail machines now being manufactured. The operation of the machines is explained in Chapter IV. In the tables, the wire range, in terms of the Steel Wire Gage, is given in addition to the penny size of the largest common nail which each machine is capable of making. The horse power required to operate each machine is also given.

TABLE II
"BROOKLYN" MACHINES

Mfr's Number	Wire Range	Nail Length	r.p.m.	h.p. req.	Largest Com. Nail
0	20 - 15	1/2 - 1"	370	1/2	2d
1	17 - 14	1/2 - 1-1/4	370	3/4	3d
2	16 - 12-1/2	1/2 - 1-3/4	335	1	4d
3	13 - 11-1/2	3/4 - 2	285	1-3/4	6d
3-1/2	12-1/2 - 9	3/4 - 3	230	2-1/2	10d
4	10 - 6	1 - 4	160	3-1/2	20d
5	7 - 4	1 - 5	150	4	40d

TABLE III
"UNIVERSAL" MACHINES

Mfr's Number	Wire Range	Nail Length	r.p.m.	h.p. req.	Largest Com. Nail
1	22 - 18	1/4 - 1"	500	1/2	2d
2	20 - 14	3/8 - 2	400	3/4	3d
3	16 - 9	1/2 - 3	300	1-1/4	10d
4	12 - 6	3/4 - 4-1/2	250	3	20d

TABLE IV.
"NATIONAL" MACHINES

Mfr's Number	Wire Range	Nail Length	r.p.m.	h.p. req.	Largest Com.Nail
5	22 - 15	1/4 - 1"	500	1/2	3d
4	16 - 12-1/2	1/2 - 1-1/2	400	3/4	4d
3	14 - 11-1/2	1/2 - 2	375	1-1/2	6d
2	13 - 9	1/2 - 3	275	2	10d
1-1/2	10 - 5	1/2 - 4-1/2	200	4	30d
0	6 - 0	1 - 9	175	6	60d
00	4 - 000	2 - 12,	150	10	Spikes

TABLE V.
"RYERSON-GLADER" MACHINES

Mfr's Number	Wire Range	Nail Length	r.p.m.	h.p. req.	Largest Com.Nail
00	20	1/4 - 3/4"	500	3/4	
0	15	1/2 - 1-1/4	400	1	3d
1	15 - 11-1/2	1/2 - 2	350	2	6d
2	12-1/2 - 9	1/2 - 3-1/4	300	3	10d
3	10 - 5	3/4 - 4-3/4	200	5	30d
4	6 - 2	1 - 6	175	7-1/2	60d

(d) KIND OF WIRE USED. All the wire nails used today are made of what is known as "hard drawn" steel wire. The usual run of nails is made of Bessemer steel, but, on special orders, nails can be made of basic open hearth steel. In any event, both kinds of steel used are of the low carbon stock.

In drawing wire, the stock gets harder each succeeding draft until for low carbon stock the wire must be annealed and re-cleaned before the smaller sizes can be drawn. In drawing nail stock, the aim is to get the final draft made before annealing is necessary so that the finished nail will possess the requisite stiffness.

In making nails having large sized heads, it is necessary to use wire made of open hearth steel, because the Bessemer steel shows a tendency to split when the wide heads are formed.

(e) ECONOMIC ARRANGEMENT OF DRIVES & MACHINES. The extent of operation of a nail mill will depend upon orders received from the trade. If the orders were always of such size that the entire output of the mill would be required to fill them, the arrangement of the drive would be simply a matter of obtaining a power unit large enough to drive the entire mill. However, experience shows that orders are not received in such convenient amounts and there are times when only a small part of the mill will need to operate.

To meet this condition, a flexible arrangement of drives and machines must be provided; that is, the machines must be grouped in such a way that several different sizes can be operated at one time and still have only a part of the mill running. This will give a small tonnage, but a varied output.

(f) TONNAGE AS A BASIS OF WAGE PAYMENT. The tonnage output of any nail machine depends upon the kind of nail being made. A glance at the preceding tables of this chapter shows a wide variation in the length of nail which can be cut and the gage of wire which can be used on any of these machines. For this reason, the weight of the output of one of two machines of the same size in one set might easily treble that of the other, even though

the number of nails cut per minute was the same on both machines.

Hence, the payment of operators on a tonnage basis would be out of the question. The method used is this. The pay is figured on the actual number of nails made per hour, instead of the weight, although the weight of the output is used as a basis of determining the number of nails made. (See column headed "Approximate number per pound" in Table I.) This gives a basis of payment which is unvarying as regards the 100% production on any machine, or kind of machine, for a day's run.

(g) ADVANTAGE OF CONSTANT SPEED. From the foregoing, it is obvious that all machines, of each separate style about the mill, must operate at the same speed. Otherwise, of two operators making the same size of nail, the one having the higher speed machine will constantly earn more than the other operator. This would be a cause of discontent and should be avoided by a careful supervision of the speeds.

(h) POWER REQUIREMENTS OF NAIL MACHINES. All nail machines are equipped with fly wheels and, once started, the belt load remains practically the same for indefinite periods. Repeated tests with a motor, equipped to drive individual machines and measure the power consumption, proves that the horse power requirement of nail machines, as shown in Tables II to V, inclusive, is very near correct. A slight variation will take place, as

between a barbed or a smooth shank nail; but the horse power required, as shown, is close for the average output of any size machine.

(i) TRUCKING OF COMMODITIES. The nails, as they are made, drop into a steel "tote box" under the machine and from there are dumped into steel hopper trucks which hold about 1500#, each. These trucks are hauled by electric storage battery tractor to the elevator, which takes them to the second floor of the cleaning department where each truck load is weighed. The trucks here are handled by man power, because of the short haul from the elevator to the tumbler and the necessity of dumping the nails when the proper tumbler is reached.

The wire from the wire mill is hauled into the nail mill by electric storage battery tractors.

VII. CLEANING AND POLISHING NAILS.

(a) IMPORTANCE OF CLEANING & POLISHING NAILS.

In the process of wire drawing, the wire acquires a thin coating of heavy grease - a coating which is very desirable from the standpoint of the nail maker, but which would be most undesirable from the standpoint of the customer if it were allowed to remain on the nails. This coating of grease on the wire acts as a lubricant for the cutting dies in the nail machine, and, for that reason, is decidedly advantageous to the nail maker. The nail wire could be produced in the wire mill without the grease coating by drawing bright wire, at a very slight advance in cost, but, since nothing is to be gained and considerable would be lost by its elimination, the coating continues to be a requirement of the nail maker.

In the nail machine, during the process of heading and pointing, slightly burred edges are acquired by the nails about the head and at the point. If the nails were sold without first removing these burred edges, it would be impossible to handle the nails as a carpenter must do without lacerating the hands.

The first waste of steel in making wire nails occurs in the process of pointing, at which time the waste

or scrap called "whiskers" is produced. These are small, diamond shaped pieces of steel cut from the wire when the nail is pointed. The "whiskers" drop into a receptacle under the machine with the nails, but during the process of tumbling the nails and "whiskers" are separated.

For the purpose of removing the grease first mentioned and to rid the nail of objectionable burred edges, it is necessary to polish and smooth the nails by tumbling them in a steel drum for a time before packing them for shipment.

In most states, in addition to the tumbling, the manufacturer is required by law to heat sterilize all lath nails, besides packing them in dust proof containers for shipment. The containers used are the standard nail kegs, made dust proof by a lining of suitable paper.

(b) NAIL TUMBLERS. The subject of tumblers for cleaning nails is one that has cost the nail companies a very considerable sum of money, for the mechanical cleaning of nails and the elimination of dirt and "whiskers" is not so easy of accomplishment as might at first seem probable.

The tumblers are cylindrical in form, with cast iron heads mounted on a 4 or 5" diameter shaft which is continuous through the tumblers. The sides are usually made of 1/4" special steel plate, containing from 3 to 4% nickel to withstand the abrasion of the nails. The plates are bent 36 to 42" in diameter and long enough to

hold fifteen to twenty-five kegs of nails. Each tumbler has a removable lid bolted onto and extending the full length of the body. This lid is double and is made up of two steel plates, curved the same as the tumbler body. A 3/16" inside plate, perforated with 1/8" diameter holes, is mounted on a 1/4" outside plate with 1/4" liners between, forming a space out of which the dirt, saw dust and "whiskers" must escape by sifting through the perforations of the inside lid plate during the period of cleaning. The outside plate prevents the nails coming through these perforations. The tumbler is charged and discharged by removing the lid.

It has been found that the most economical method of tumbling nails is to handle them in lots of fifteen kegs or more at a time. This reduces to a minimum the labor of weighing at the packing scale, the labor of heading kegs and the labor of storing nails in the warehouse by having several kegs of the same size nails to handle at one time.

(c) POLISHING MATERIAL. The cheap, but effective, polishing material for wire nails is common sawdust and it is used universally for that purpose. It is put into the tumbler with the nails, and, during the tumbling period, is gradually eliminated with the dirt and "whiskers" by sifting through a finely perforated false cover. The dirt, sawdust and "whiskers" drop into the hopper under the tumbler, as shown on Plate VI. When the tumbler is

rid of all sawdust and "whiskers", the hopper is cleaned out, after which the nails are dumped from the tumbler into this hopper and from there packed in kegs and sent to the warehouse. It is not customary to use sawdust of any particular wood, because the sawdust of all woods seems to answer the purpose equally well.

(d) TIME REQUIRED TO CLEAN. The tumblers are usually run at a speed of about 20 r.p.m. After the tumbler is charged, it is run for a period of an hour to an hour and a half depending upon the condition of nails to be cleaned. One and one-quarter hours is not an unusual period required to clean nails.

(e) PREVENTING BENT NAILS IN CLEANING. In cleaning nails in a tumbler, care must be exercised lest considerable damage be done by bending the nails. This usually occurs as a result of the nails catching in some point in the sides or ends of the tumbler which has worn out and needs replacing. Some few years ago, a many sided tumbler, say ten to twelve sides, was quite popular. However, it was found that the nails rapidly wore the joints between the faces and the result was many bent nails. These tumblers have been replaced for the most part by those of the cylindrical steel drum type, free from construction joints in the sides.

The round tumbler has proved very satisfactory. From four to six steel angle irons should be riveted to the side of the tumbler, parallel to the shaft, to break

the slide of the nails around the circumference as otherwise the tumbler will wear rapidly. Common carbon sheet steel for the sides will not last over one to three years, while hard steel has been known to give service for twenty-six years in a nail tumbler.

Nails bent in tumbling are easily overlooked and once put into the keg and sent to the warehouse no more is heard from them until a complaint is received from the customer. The prevention of bent nails is important. The price is vigilance and the remedy is frequent and systematic inspection of all nail tumblers.

VIII. PACKING AND STORING NAILS.

(a) USUAL NAIL PACKAGE. It has been the custom in America for a number of years, before the days of wire nails at least, to use a wood keg for the shipment of nails. This keg is of such size that it will hold net 100# of nails, which is also an American custom. Kegs have been standardized now as much as possible, which is of great advantage in a large warehouse where kegs of several manufacturers must all be piled together.

The standard keg is made of bilge sawed staves, 18" long, and, before the keg is assembled, the material is all kiln dried. No attempt is made to produce a water-tight keg, as was once the custom in making nail containers. On account of the growing scarcity of wood and the consequent increasing cost of it, numerous patents have been issued covering the design and manufacture of steel containers for nails, but without much practical success. In unheated warehouses, the steel package is a contributory cause of spoiled nails from rusting as this package will sweat in damp weather. Besides this objection, the lightest steel keg is heavier than one made of wood and, for this reason, would cause a large loss in freight due to the increased weight of the container. It is safe to say that

the day is far away when steel containers for nails will replace those made of wood.

Special nails are packed in suitable boxes of any description to please the customer.

(b) PARALLEL PACKING OF NAILS. The standard nail keg is 18" long by 9 to 11" in diameter, depending upon the size of nail to be packed. It is a fact that nails dropped promiscuously into a package occupy more room per pound that when arranged systematically. Actually, the systematic method of packing nails will permit the use of a keg 1" less in diameter than that required by the promiscuous method. The cooperage thus saved in the course of a year's run in a large nail mill will amount to several thousands of dollars in value.

The method of systematically arranging nails in the package is simple. A funnel, provided with four parallel steel partitions, long enough to extend almost to the bottom of the nail package, is dropped into the keg to be packed. The keg is then placed under the lower edge of the shelf of the tumbler hopper and the nails are raked into the keg through the funnel, while the keg is kept in vibration by means of a rigid connection to a small throw eccentric on a shaft under the tumbler, as shown on Plate VI. The function of the funnel partitions is to cause the nails to parallel as the keg is vibrated, thus economizing room in the keg. The keg is vibrated

about 350 times per minute. This gives a compact and systematic arrangement of the nails in the package.

In 1916, a Swiss by the name of Otto Gamper invented a magnetic nail packer whereby nails were drawn parallel to the lines of magnetic force while dropping into the package. This packer was based on the principle that linear articles of iron, when brought into a magnetic field, automatically take a position parallel to the lines of force. The outfit is primarily for packing special nails, such as foundry nails, in small boxes, but its practical value in a large mill is still to be proved. Up to the present time, it has not been extensively adopted.

(c) PACKING MACHINERY. After the kegs are filled with nails at the tumbler, the keg, still without the head, is placed on a floor type conveyor which delivers it to the scale for final weighing. The net weight of the nails, regardless of size, is made 100#. After leaving the scale, the head (properly stencilled with size of nails, and maker's name) is put on by hand together with the top hoop which is pressed home in a head press machine. The keg is now rolled by gravity to a nailing machine, which nails the top hoop through to the head. From the nailing machine, the keg is delivered to the warehouse by a conveyor.

(d) STORAGE OF NAIL KEGS. When the supply of nail kegs is depended upon to come from the outside, a shutdown due to a delay in shipment must be guarded against by providing storage for enough kegs to tide over

any reasonable delay. The kegs are light and no special type of building is necessary. The place of storage should be located where the cost of handling and re-handling is cut to a minimum. This would be near the packing room and near a side track.

(e) THE STORAGE OF NAILS. The logical size of the warehouse for finished nails is only to be determined by the policy of the manufacturer as to the quantity of finished stock to be carried. The net floor area determined upon must be increased for the necessary aisles and truckways between piles of various sized nails, as each size should be kept in a section by itself and accessible in case nails from this section were wanted to fill an order.

The nail warehouse must be dry. It is not necessary to have it heated, but it should be well ventilated. The floor must be dry at all times, else the nails will rust. Besides being dry, the floor must be capable of sustaining the weight of loaded kegs piled to the ceiling, which it will be subjected to during a time when the policy of the manufacturer is to accumulate a large stock of finished nails.

The warehouse should be located where switch tracks are accessible without bothering the other departments of the plant. The use of a covered loading platform is strongly recommended, as the loading of any number of cars is possible by extending the platform the required amount, without altering the building. The cover is a

protection to both nails and employes when loading in stormy weather.

It is essential that the warehouse be isolated from the cleaning department, or any other department where dust is raised; otherwise, the nails will get dirty if stored for any length of time and this will give rise to complaints from the customer.

IX. NAIL DIES.

(a) KIND OF STEEL BEST ADAPTED. A considerable item of expense in the operation of a nail mill is involved in making the cutting and pinch dies and the heading hammers. Both cutter and pinch dies are made from beveled shapes sold by the tool steel makers and known as "Wire Nail Die Shapes". These shapes are made up in bars beveled at an angle of 10 degrees, on two edges, so that no machinery is necessary to fit the die into the die holder of the machine.

The grade of steel best adapted for cutter dies is one of the high speed varieties. High speed steels are the only ones that will stand up on Bessemer steel wire at the speeds which nail machines are operated, because of the heat generated in heading and cutting. The life of the dies is longer when cutting open hearth steel.

Pinch dies made of high speed steel will stand up the longest, unless they are accidentally broken. This rarely happens except on 20d to 60d sizes, where, on account of the higher pressures necessary to hold the wire for heading, the dies are sometimes split in two. For these larger machines, No.5 temper common tool steel

is sometimes used; then, if the die splits, the cost of the tool steel lost is not as great as for the high speed steel.

The hammer heads are made of machinery steel having a counter-bored hole in one end, into which is pressed a hardened, high speed steel plug. The hammer can then be repaired by renewing the plug, which forms the head on the nail.

(b) HARDENING AND TEMPERING. The die maker cuts steel into the required lengths for various dies and performs the few necessary machine operations on the pieces to prepare them before hardening. They are then heated in a gas furnace and tempered in oil, all in strict conformity to the steel manufacturers instructions for that particular grade of steel. After hardening, the dies are finished by grinding.

(c) ECONOMIC UTILIZATION OF TOOL STEEL DIE SCRAP. After being used for a period of twenty to twenty-four hours operating time, the cutter dies get dull. They can be reground once or twice, after which they must be annealed and remade. In time, they become too short to be easily handled, but by the use of the oxyacetylene torch a piece of soft steel can be welded on the die and the original length restored and the useful life of that particular piece of tool steel prolonged accordingly.

(d) MACHINERY REQUIRED. The amount of machinery required to operate a die room is not extensive. A cold

saw, with automatic attachment, is required to cut the tool steel bars into die lengths. A small milling machine and an 18" shaper will take care of the necessary milling and shaping of the cutter and pinch dies. A three- or four-vertical multiple spindle sensitive drill is required for the pinch dies and some styles of cutter dies. Two nail die grinding machines, with universal die holders, for grinding the pointing dies are necessary. The "Universal" machine, built by the makers of the "Universal" nail machines, gives excellent results. This is one of the very few machines made for the work of grinding nail dies.

To complete the equipment is needed a No.1 gas fired oven furnace for both heating and annealing the dies, and a gas heated oil bath for tempering some grades of dies. The operation of these gas furnaces requires a positive blower to furnish the air.

X. DESIGN AND DESCRIPTION OF A TYPICAL NAIL MILL.

(a) STATEMENT OF PROBLEM. While engaged in the engineering department of a large steel wire drawing plant, the writer was required to lay out, and later build, a complete mill for the manufacture of all commonly used, standard wire nails. This mill has been in operation for the past few years and has a capacity of about 100 net tons of finished nails every ten hours. The experience gained in that undertaking and the facts gathered from comparative observations made at other nail manufacturing plants form the basis of this description, which is typical of the modern, American nail mill. The present state of the art of making nails, described in detail in the preceding chapters, is given for the purpose of making clear the various points influencing the design of this type of mill.

It was desired to increase the finishing equipment of the plant to dispose of about 100 tons of plain drawn steel wire, daily, which amount could be furnished from the wire mill in almost any size, from rods down to 15 gage wire. The manufacture of nails filled the requirements nicely, because equipment could be purchased to use all common sizes of wire in some quantity. Just what the total quantity would amount to, in tons of wire, with

the nail mill running full, could not be accurately foretold, because the tonnage output would only be determined by the style of nails to be manufactured to meet trade demands.

To illustrate how these trade demands cause a variation in the tonnage requirements of wire, a #9 x 1/2" roofing nail and a 10d common nail are both made of the same gage wire, on the same size machine, and at the same number of nails per hour. The roofing nail is 1/2" long and an hour's run on the machine weighs 68#: the 10d nail is 3" long and an hour's run on the machine weighs 248# - a difference of 112# in favor of a higher tonnage in the case of the 10d nail.

In order to establish an arbitrary tonnage for the production of the mill, for the preliminary work of design, only the common variety of nails was considered in the output, altho the same machines are adjustable to make all styles of nails within their range of length and gage.

(b) OUTLINE OF DESIGN. In the designing of a nail mill, the first requisite is a comprehensive knowledge of the operation of nail machines and nail making methods. The first step was to outline the general plan, bearing in mind the mechanical operation, superintendence, co-ordination of new and existing divisions, routing material and future expansion.

In general, a nail mill has three divisions - each one subdivided, as follows:-

I. MANUFACTURING.
   1. Nail Machines
   2. Handling Material
   3. Building

II. CLEANING AND PACKING.
   1. Cleaning Machinery
   2. Packing Machinery
   3. Building

III. WAREHOUSE

(c) SELECTION OF NAIL MACHINES. The nail machines, of all equipment in the nail mill, are of the utmost importance and it is upon their selection that operating costs largely depend. Operation of the principal nail machines is explained in Chapters III and IV. In connection with the design of the nail mill in question, it was proposed to do necessary repair work on the nail mill equipment in the machine shop used for repairs in the rest of the plant. This was a factor in the choice of new equipment, care being taken to make sure that all parts could be made in this shop. The first cost was not necessarily a governing influence in their choice. In addition to the new machines to be purchased, there were several second hand machines available for use and these were included in the equipment.

After a careful survey to determine the quantities of various sizes of nails to be made, the total number of machines was placed at one hundred sixty-two and divided as between the number of each size required. The estimated

tonnage output and horse power required to drive the machines were taken from the data in tables shown on pages 47 and 48.

(d) BUILDING. The general character of nail making machines, which is explained in more detail in the preceding chapters, together with the weight of the output make it desirable to have the nail making done on the ground floor, where each machine can be placed on an individual foundation. The building is not then subjected to the excessive vibration obtaining where machines are operated and heavy loads trucked on an upper floor.

The floor space required for each machine is not large, and the working spaces can be arranged in straight lines. No working space is required back of the crank shaft for the operation of the machines. This being the case, the machines can be arranged in a double row along the mill, with the line shaft carried overhead between two single rows of machines which are driven by individual belts from this line shaft.

A truckway, over which the nail wire is brought into the mill and the nails taken away to the cleaning department, is required in front of each single row of machines. In addition to this truckway, space within easy reach of each machine is required in which to stock the wire which is to be cut into nails. This space can best be supplied across the truckway from the machines.

The general arrangement of the entire nail mill, and its relation to the rest of the plant, is shown on Plate I. The wire mill, shown at the top of the plate and directly across the track from the nail mill, is the source of supply for nail wire drawn to size. This is delivered to the nail mill on trucks, drawn by electric storage battery tractors, and is left on the truck just as piled in the wire mill until wanted for the nail machine. This practice necessitates a large equipment of trucks, but pays well by eliminating the labor otherwise required to unload the trucks and pile the wire on the nail mill floor.

The mill is divided into two sections, in order to keep the length of the building within reason and still have enough room to install the required number and sizes of machines. If the length of the mill is such that supervision cannot be maintained by the foreman from some centrally located position, his work will be slighted. Therefore, the office space of the foreman is located at one end of the mill, as shown on Plate I, from which point he can easily direct all operations without an assistant, thus cutting the overhead expense of superintendence to a minimum.

This arrangement also gives two entrances to the nail mill from the wire mill, which prevents congestion of traffic between mills and makes a shorter average haul than would be the case if the nail mill were

one long stretch. It also provides a possible means for nail mill expansion, as shown by dotted lines at the right on Plate I, without increasing the average haul of wire from the wire mill or of nails to the cleaning department. Also, in case wire is received from the outside for making nails, a car can be set at one entrance of the nail mill without interfering with the traffic between mills at the other entrance. This is a feature worthy of consideration, because it does not require any adjustment other than the established routing of material through the mill.

Plates II and III show the plan of the nail mill by sections, each section drawn to a larger scale and more in detail than was possible on Plate I. Plate IV shows a cross section of the nail mill.

The type of building selected is that known as "Mill Construction". This type forms a substantial part of the original group of mill buildings and was the determining factor in its selection. In construction, the building is of the slow burning type, which, in this open style of structure, is most desirable from the fire hazard standpoint.

A monitor in the center of the building, extending the entire length of the mill, is of ample height to provide good light and air throughout the building. This monitor forms an excellent means of ventilation, through the sash along both sides.

The roof is flat with a 5-ply, built-up-gravel covering and supported on 3" center-matched planks. The joints of the planks are broken over the rafters, which are 8"x16", laid on 8-ft centers, and form a substantial support for the 3" plank roof and also for shaft hangers which are lagscrewed to them.

With the spacing of 8-ft center to center of the shaft hangers, a 5 h.p. drive can be installed anywhere on the 3" shaft without danger of deflecting it in the least. This fact determined the adoption of a 3" line shaft for the machine drive.

The floor is 1-1/16", end-matched, factory grade hard maple, laid on and at right angles to the plank of a 3" creosoted sub-floor, which is continuous under the runways and the maple. The 3" plank is insulated from any moisture from the earth by a 1" cushion of sand, which is thoroughly tarred and compacted while hot and laid on a 3" foundation of either cement or tar concrete - preferably the former. If carefully laid, this floor is durable and stands up well under heavy trucking. A poor floor should not be tolerated. It occasions loss of time in moving material and is often the cause of accidents to employes, because of the occurrence of badly rotted places.

The truckways are formed of 1" cast iron plates, 4 by 6-ft in size, and weighing about 950#. The surface is crosshatched to prevent slipping. There are two

objections to the use of these plates. First, they become very slippery, making them difficult to walk upon, and thus are the cause of some accidents: second, they are constantly subjected to heavy trucking which seems to cause the upper side to elongate and the plates soon bow up in the middle. These objections are hard to overcome and steel plates are subject to the same trouble. However, with the two defects just named, cast iron plates have proved more satisfactory than steel in the long run and they work in nicely with the 1-1/16" maple used in the floors.

All window sash are of wood. However, if the building were of more than one story and the question of light of equal importance, the type of building could be changed to one supported on steel framework and with lighter sidewalls containing steel sash. This would make up for loss of light from the monitor, which would necessarily be eliminated so far as the first floor is concerned. The sash in the side walls are of the check-rail type, while the monitor sash are single and center-pivoted. The center-pivoted monitor sash are far superior to the top-hung type, where ventilation is to be considered. The former permit the escape of heated air, which naturally accumulates in the top of the monitor, while the latter tend to entrap this air and thus retard ventilation.

Ventilation is also greatly improved by the installation of a forced-draft heating system. In winter,

the air is tempered by being blown through a bank of steam heating coils and then into the room. It is a well demonstrated fact that a mill is more comfortable at a lower temperature when heated with fresh air, than when heated with steam coils alone.

This was especially noticeable in the cleaning and packing room. When heated by steam coils, it was impossible to keep the dust down even with the windows open - which they always were except in the most severe winter weather. However, when properly heated fresh air was blown into the room, the dust settled rapidly and working conditions were greatly improved.

In a manufacturing department, the arrangement of steam heating coils is important. If carried overhead, they usually have a peculiar effect on the workman. His head is too hot, causing headaches, while his feet are too cold for comfort. An arrangement whereby steam heating pipes are carried along the wall near the floor, or the use of floor radiators, is satisfactory because it produces a better circulation of air in the entire room. The coils, however, are subject to frequent repairs, made necessary by their being hit with loaded trucks. This is another reason for the installation of a blower system, where the air pipes can be carried overhead and the air deflected downward.

(e) NAIL MACHINE DRIVES. The extent of operation of a nail mill will depend upon the orders received for

nails from the trade. If these orders were always of such size that the entire output of the mill would be required to fill them, the arrangement of the drive would be a simple matter of obtaining a power unit large enough to drive the entire mill. However, experience shows that orders are not received in such convenient amounts and there are times when only a small part of the mill will need to operate. To meet this condition, a flexible arrangement of drive and machines must be provided; that is, the machines must be grouped in such a way that several different sizes can be operated at one time and still have only a part of the mill running. This will give a small tonnage, but a varied output.

Careful examination of Plates II and III, noting the various sizes of machines grouped for each of the four drive shafts extending the length of the mill, will make this scheme clear.

The driving units selected are electric motors, as shown. The power demanded of each is such that no unusual sizes are required. They do not occupy excessive floor space and operate without fumes or dirt. They require no regular attendant, except periodic inspection by the plant electrician.

(f) CLEANING AND PACKING BUILDING. The cleaning and packing building, also the warehouse, are, like the nail mill, of slow burning mill construction, but with this exception - the second floor of the cleaning room is

of reinforced concrete, supported on structural steel. This change is made because the concrete is fireproof in itself; no dust filters down to the floor below as it will through the cracks of a board floor; and no oil soaks through, making a dirt catcher of the ceiling below. The only parts of the building which are two stories high are the elevator section, the part over the empty keg storage, and that over the tumblers. By making these parts two stories high, the gravity system of cleaning nails can be used, as explained. The remainder of the buildings, including the warehouse for finished nails, are of one story mill construction, the same as the nail mill proper.

(g) TUMBLER DRIVES. From actual tests on similar nail tumbling machines, it has been found that from 3 to 5 h.p. are required to start each tumbler - the power requirements depending upon the kind of nails being tumbled. After the tumblers get well under way, the power required drops materially. As shown on Plate VI, the drives for the four lines of tumblers are located under the floor beams and suspended from them. The main drive shafts are installed for each group of tumblers, from which individual belt drives are extended to each one of the tumblers and provided with a tight and loose pulley so that any tumbler can be independently shut down.

Each of the line shafts is driven by a 40 h.p. electric motor, which provides an estimated power

requirement of 4 h.p. for each of the tumblers. In all probability, they operate on less than that. Any additional power required to start the tumblers can be taken care of on the overload capacity of the motor, which will be only momentary. In view of the fact that at least one tumbler on each line shaft will be down for charging, and that only one tumbler will be started at a time, the 40 h.p. motor will provide ample power.

The power for operating the nail keg shaker for packing is furnished by the same motor. Only about 1 h.p. is required for this work and, while the shaker is in operation, the corresponding tumbler, which has just been emptied, is down for charging; hence, no overload is put on the motor in thus operating the shaker.

(h) SAWDUST STORAGE. To meet the requirements for sawdust, used in cleaning, a storage bin has been provided on the second floor of the cleaning department capable of holding two carloads of sawdust, as shown on Plate V. This quantity is sufficient to cover the requirements of the nail mill for a period of six weeks. Since the sawdust is used on the second floor, this is the logical place to store it.

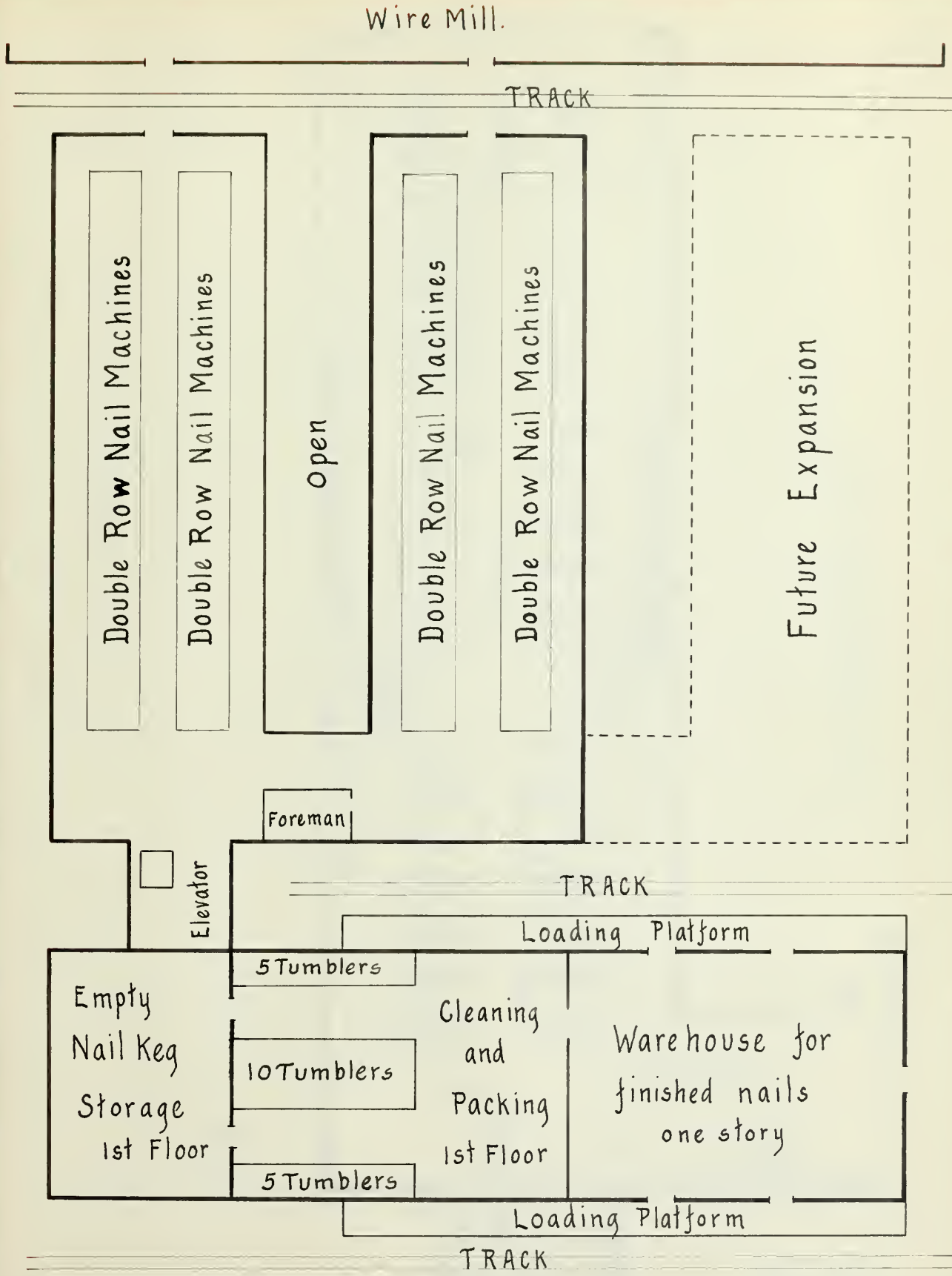
For the purpose of unloading sawdust from the car and elevating it, a direct-connected, electric motor driven blower, having a 20" suction pipe, is mounted on the ground floor and connected to the storage bin by a 20" blower pipe, which extends to a centrifugal dust collector on the roof over the sawdust bin. From here,

the sawdust drops to the storage bin below. Care should be taken not to mount the fan where a lift must be made by the suction end of the blower system.

A pipe smaller than about 18" in diameter, with corresponding blower, is not satisfactory. The carrying capacity of such an air system is about 25% of the volume handled by the blower. Since the sawdust is received in cars and handled in the car to the suction end of the pipe, in scoop shovels or coke forks, a pipe smaller than 18" is overloaded and soon stops up.

(i) NAIL WAREHOUSE. No recommendation is made as to the logical size of the warehouse for finished nails. As stated before, these dimensions are best determined by the policy of the manufacturer as to the size of the finished stock to be carried. The warehouse shown on Plate I will hold about twenty-five carloads of nails.

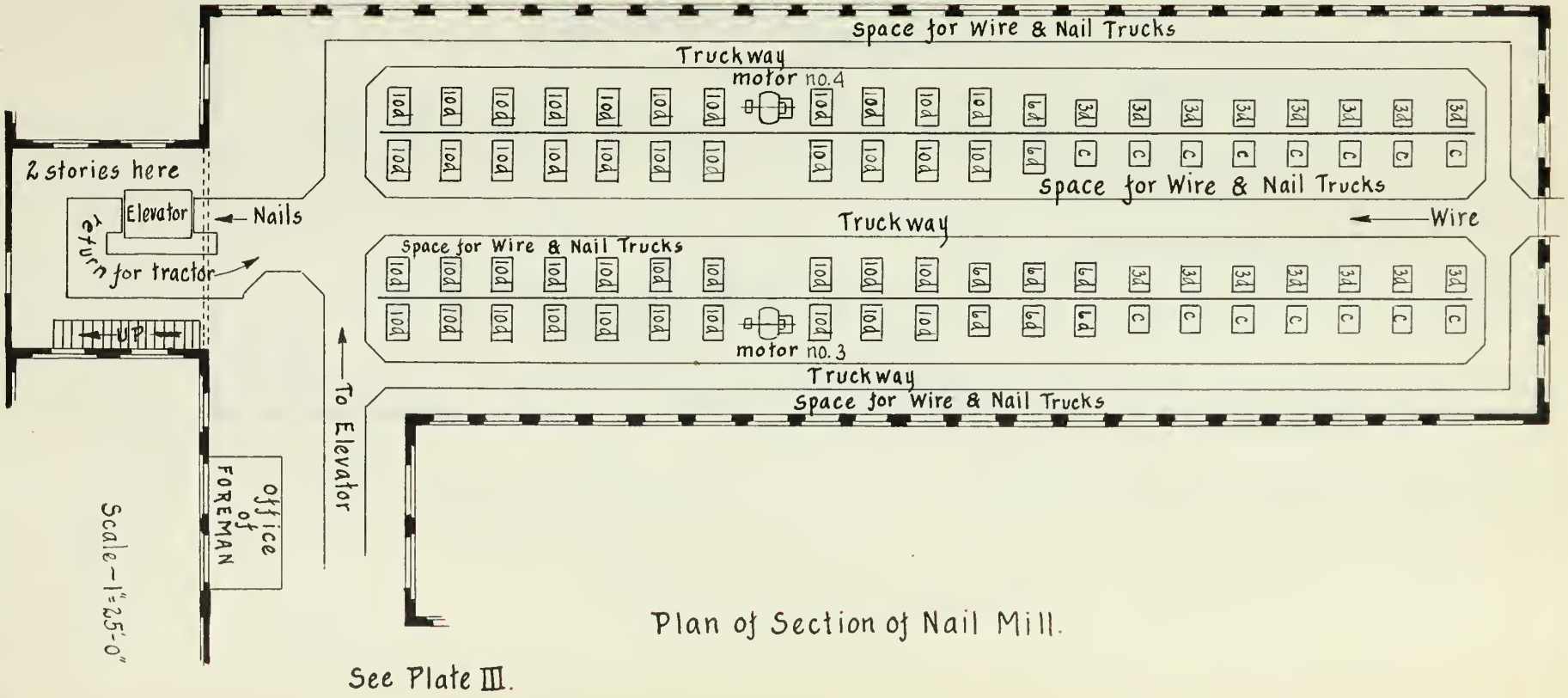
A cross section of the warehouse is shown on Plate IV. It is practically the same type of building as the nail mill, except that there are no side windows. The tar concrete sub-floor keeps the nails dry and thus prevents rust. A covered loading platform extends on each side of the warehouse, as shown on Plate I. This permits the loading of several cars with a minimum of truckways on the inside of the building, leading to the cars, and the cover affords protection to both nail stock and employes during stormy weather.



General Plan Nail Department

Scale - 1" = 40'-0"

PLATE I



Plan of Section of Nail Mill.

See Plate III.

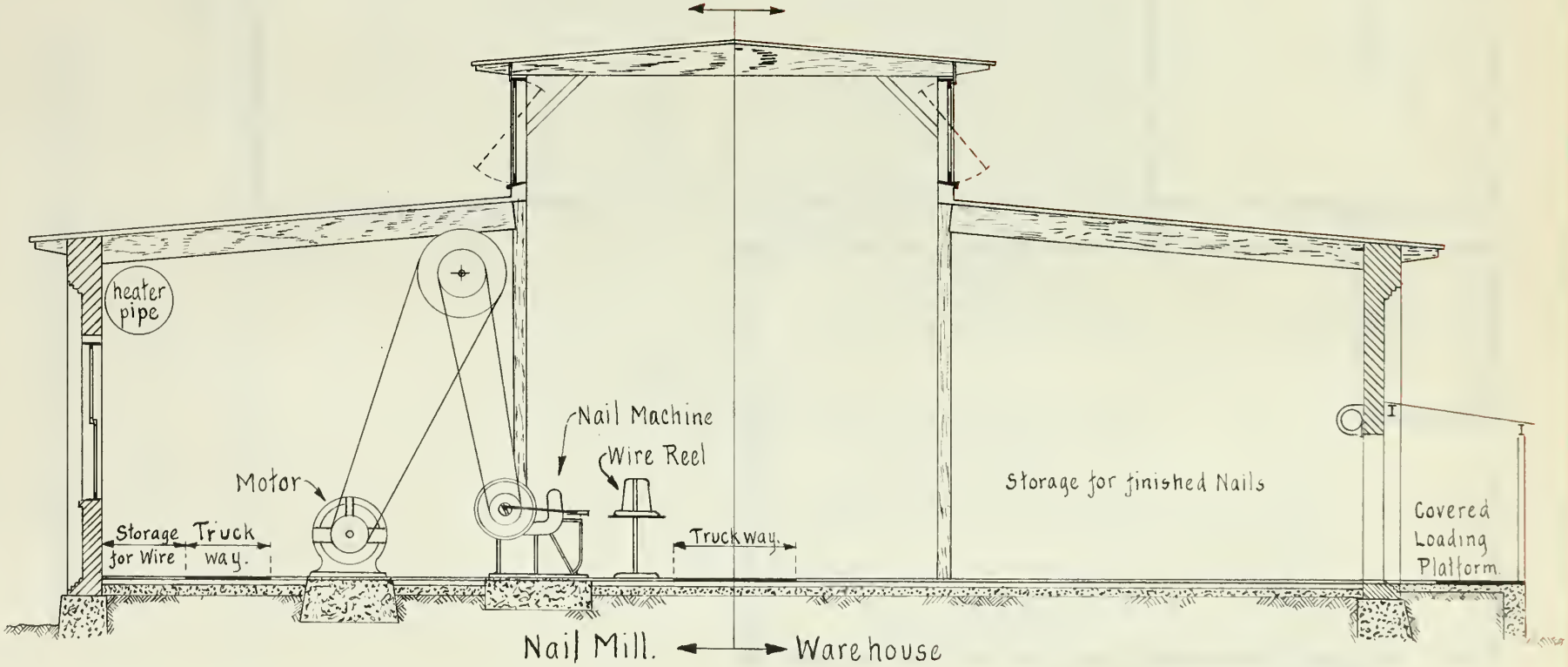
(79)

PLATE II

Plan of Section of Nail Mill

Scale 1"=25'-0"

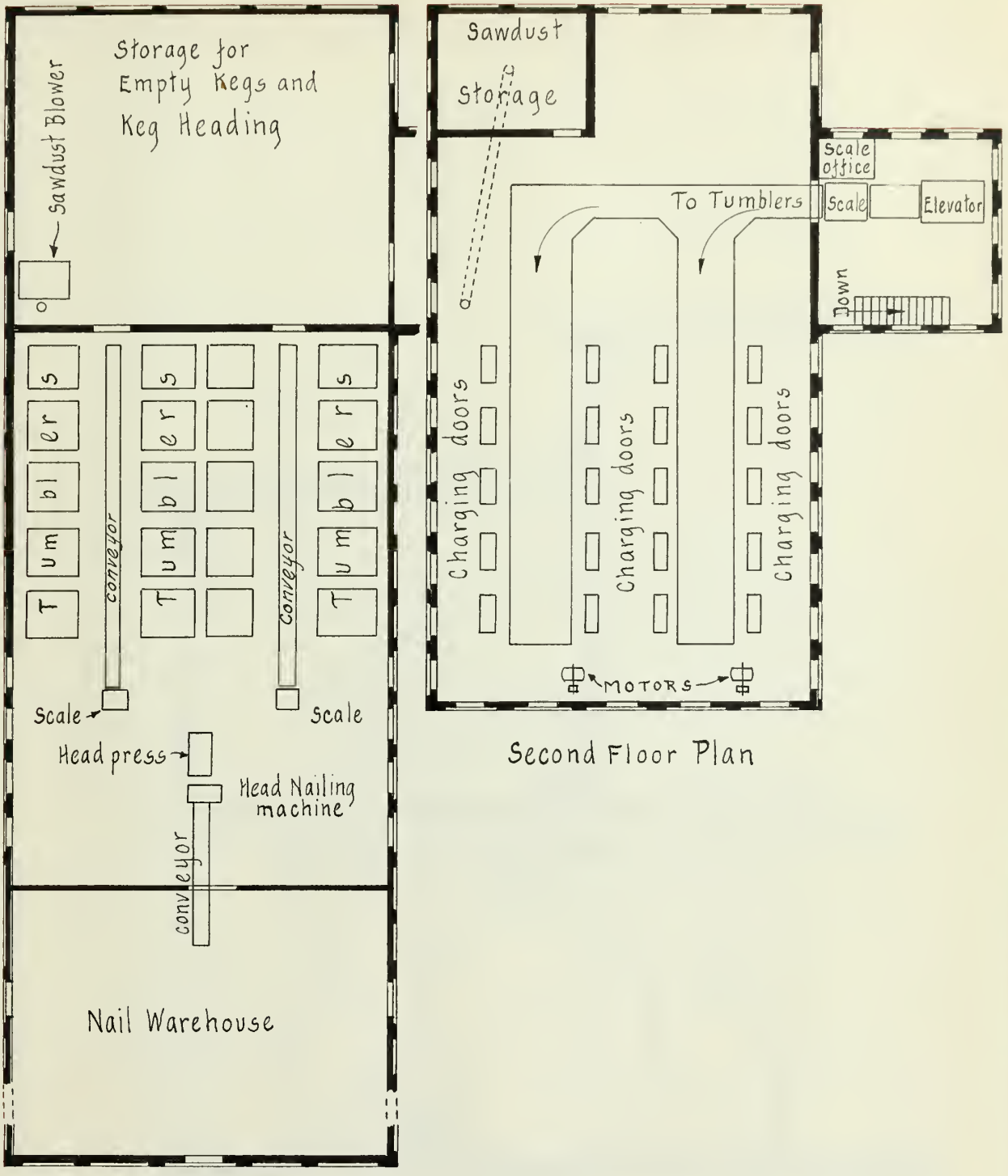
PLATE III



Scale – 1" = 8'-0"

Typical Sections.

PLATE IV



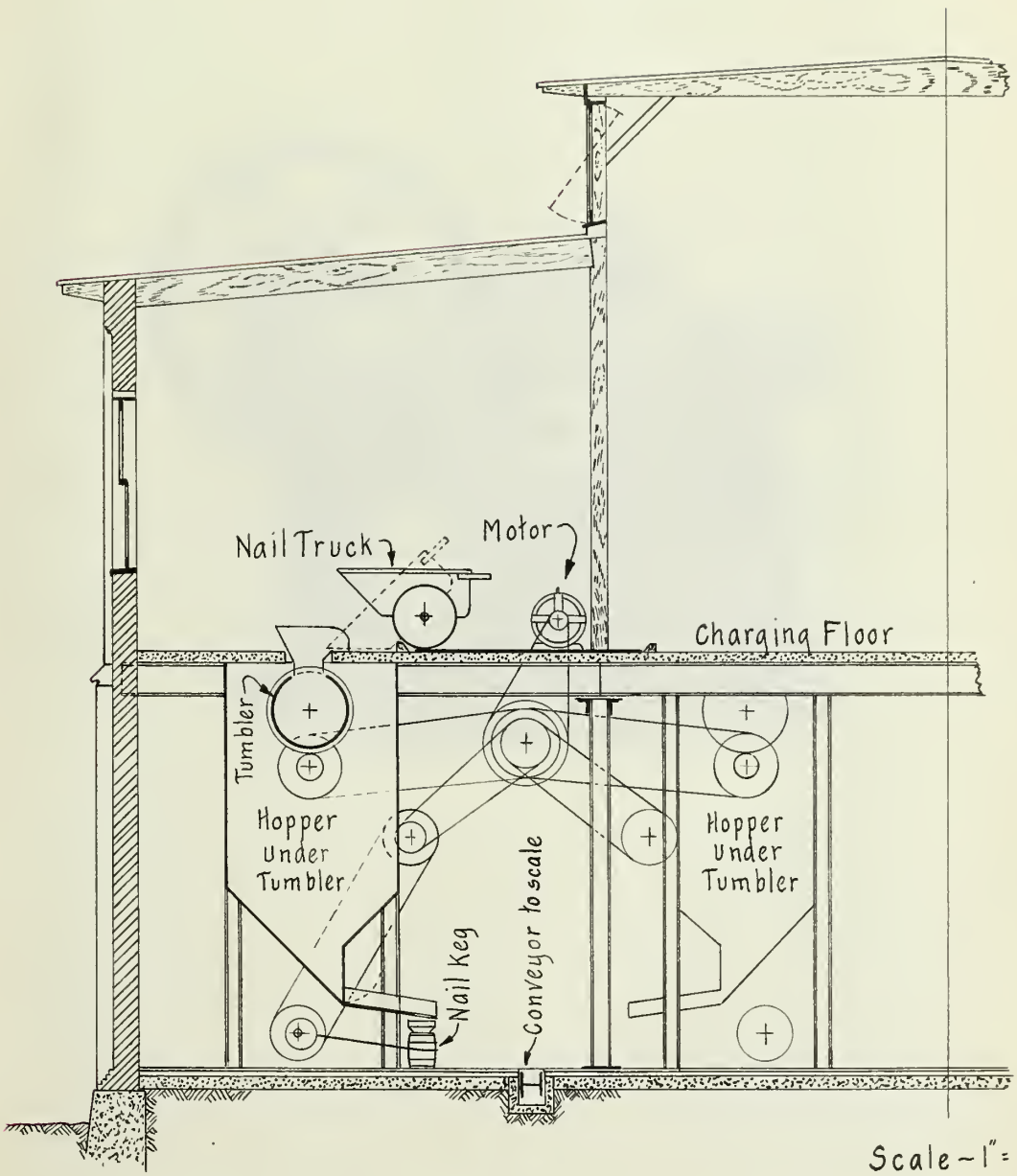
First Floor Plan

Second Floor Plan

Scale – 1" = 25'-0"

Plan of Cleaning and Packing Department

PLATE V



Typical Section Cleaning Building.

PLATE VI

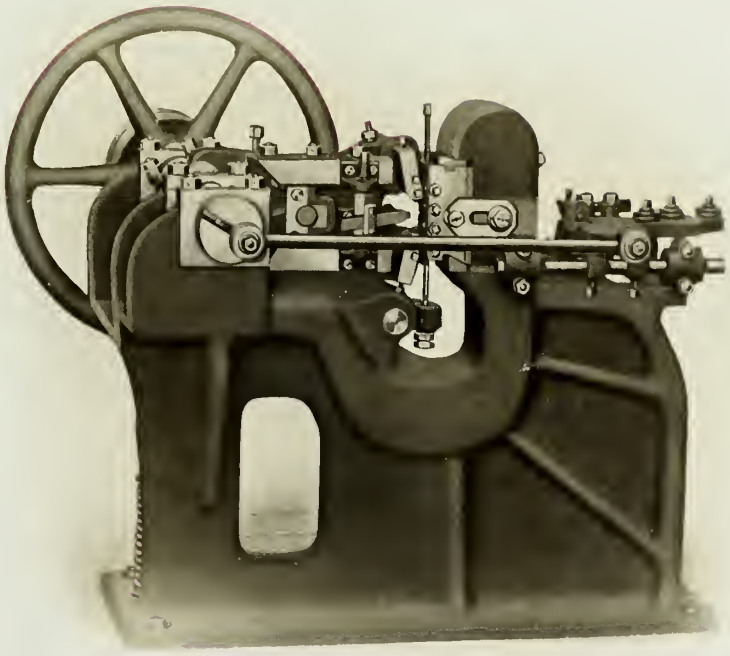


Figure I.

No. 2 National Nail Machine

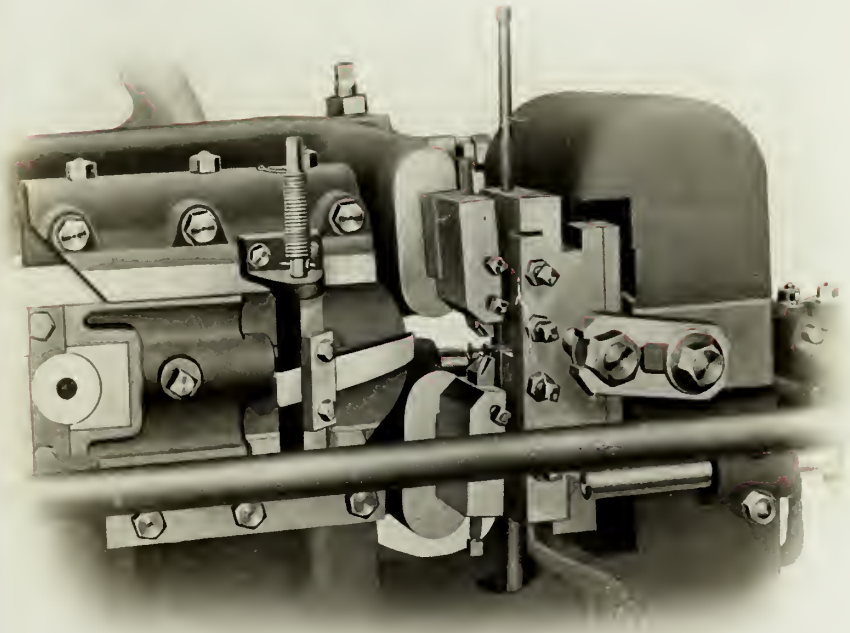


Figure II

National Nail Forming Mechanism

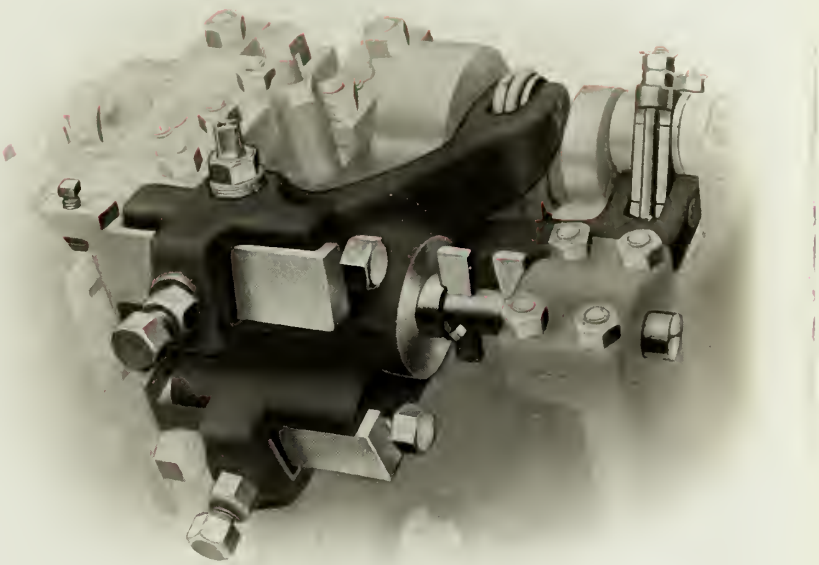


Figure III
National Cut Levers

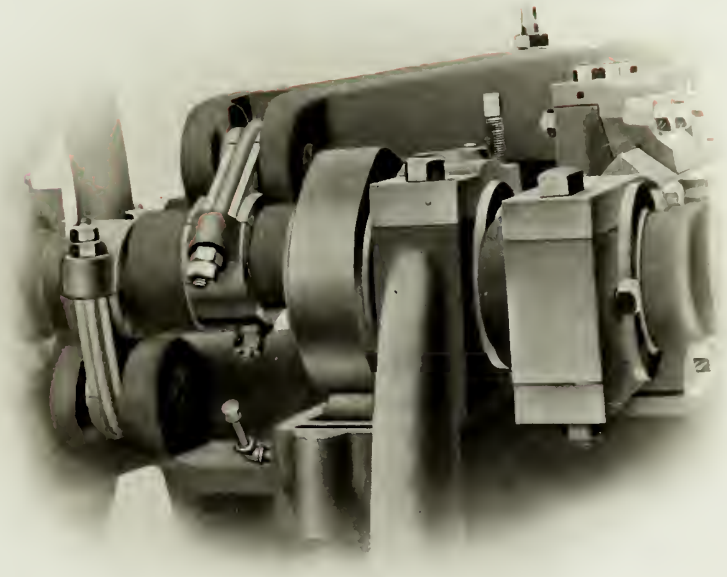


Figure IV

National Radius Links

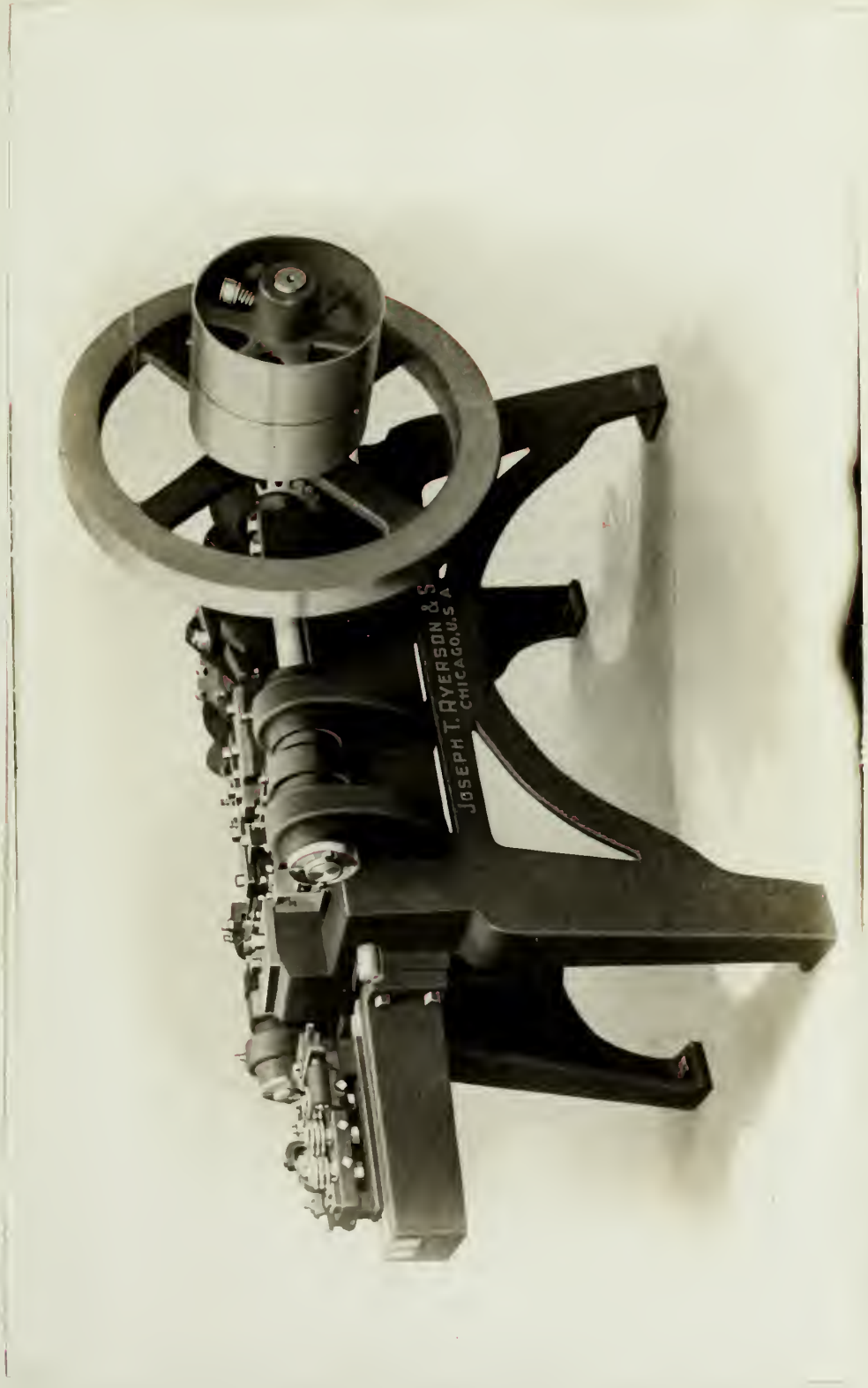


Figure V

Ryerson-Glader Nail Machine

UNIVERSITY OF ILLINOIS-URBANA
3 0112 099086487